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THE

AMERICAN NATURALIST

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PREHISTORIC HAFTED FLINT KNIVES.

CHARLES C. WILLOUGHBY.

THE question of the function of the stone implements commonly called arrow and spear points has been a vexed one. There are few references by early writers to the use of chipped flint by the American Indians for other purposes than as points for projectiles. It is very probable, however, that a majority of these implements were used as knives or cutting tools and were attached to short handles of wood or antler.

Major Powell found such knives in use among the Pai Utes. Colonel Ray collected similar implements from the Hooper valley Indians of California, and there is in the Peabody Museum at Cambridge a fine collection of leaf-shaped jasper blades fastened with pitch and cord wrappings to short handles of wood. These were obtained from the Klamath Indians of southern Oregon.

The finding of a few similar tools with wooden hafts still attached in prehistoric burial caves, cliff houses, and graves, shows that such implements were in use in prehistoric times over a large portion of North America. Prof. F. W. Putnam

has described and illustrated hafted stone knives from graves in the Santa Barbara Islands and from prehistoric burial caves in the state of Coahuila, Mexico; also one knife with a handle of antler from a mound in Ohio.[1]

The blades of the eight knives from the mummy packs of the Mexican burial caves referred to above are chipped from light-colored chalcedony, the largest one being seven and one-fourth inches in length, and its greatest width being three and one-fourth inches. The smallest blade is three and one-fourth inches long and two and one-fourth inches wide near its base. The blades vary in form, some being proportionally short with rounding points, others being comparatively narrow and sharply

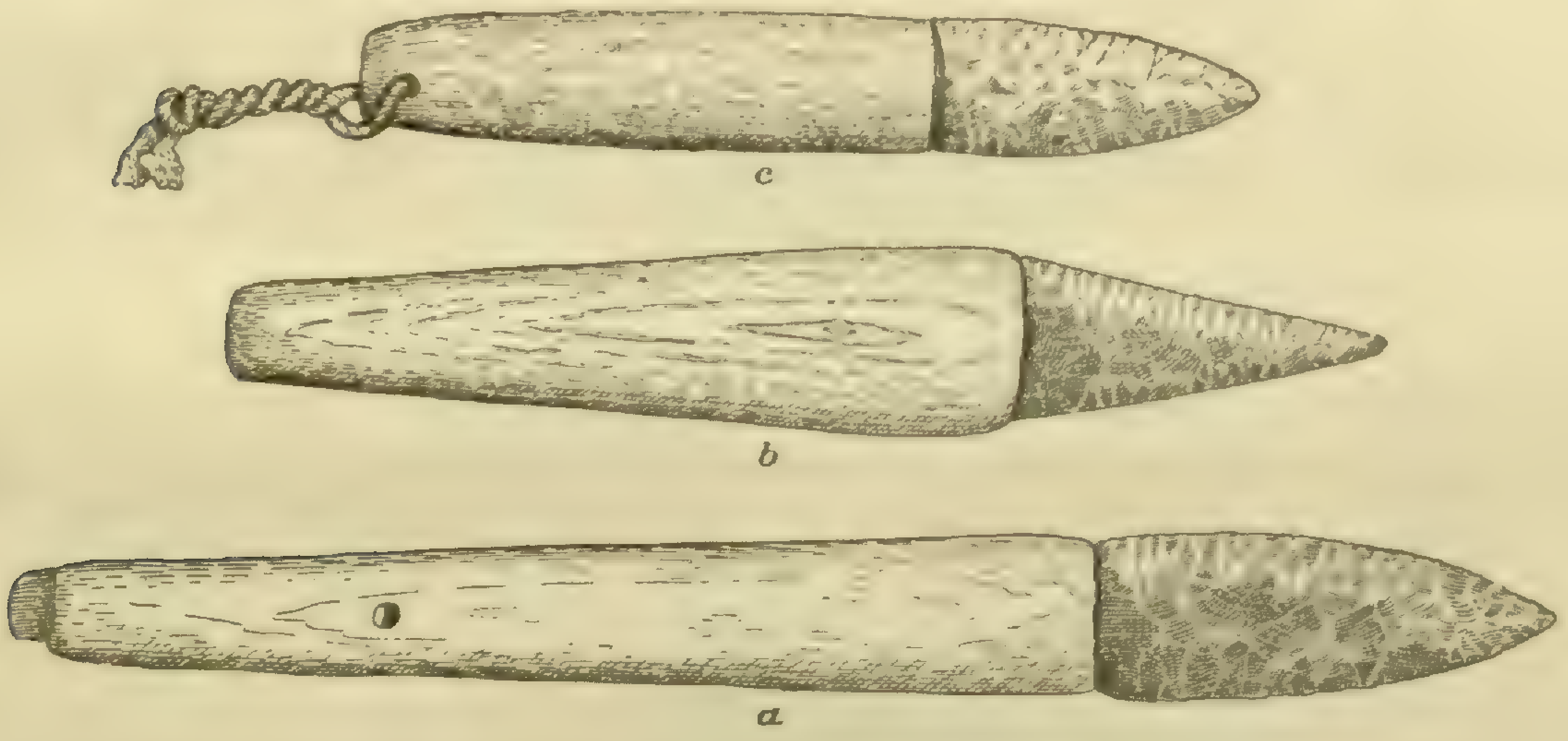

FIG. 1. — Prehistoric knives from the cliff houses, ½.

pointed. The hafts of these knives are of wood, about six inches in length, the majority of them being made of a section of a limb with the bark removed. One is fashioned from the discarded hearth of a fire-making set, and still retains the burnt depression in which the fire drill revolved. The thin base of the blades is inserted into a notch extending across the end of the haft, and is fastened with gum.

The knives from the Santa Barbara graves have small blades of flint of the leaf-shaped type. The hafts are of split wood, the blades being inserted into a notch at one end and secured with asphaltum.

[1] *Bulletin of the Essex Institute*, vol. xv, 1883; Wheeler's *Survey West of the 100th Meridian*, vol. vii; *Peabody Museum Reports*, vol. iii, p. 457.

The knife from the Marriott mound, Ohio, has a blade of black flint, nearly triangular in outline, inserted into a notch cut in the larger end of a curved antler prong. This knife and those from the Mexican caves, together with one from the Santa Barbara Islands, are on exhibition in the Peabody Museum.

While studying the remarkable collections from the cliff houses of the Southwest collected a few years since by the state of Colorado and by private individuals, the writer had unusual opportunities for examining a number of prehistoric flint knives

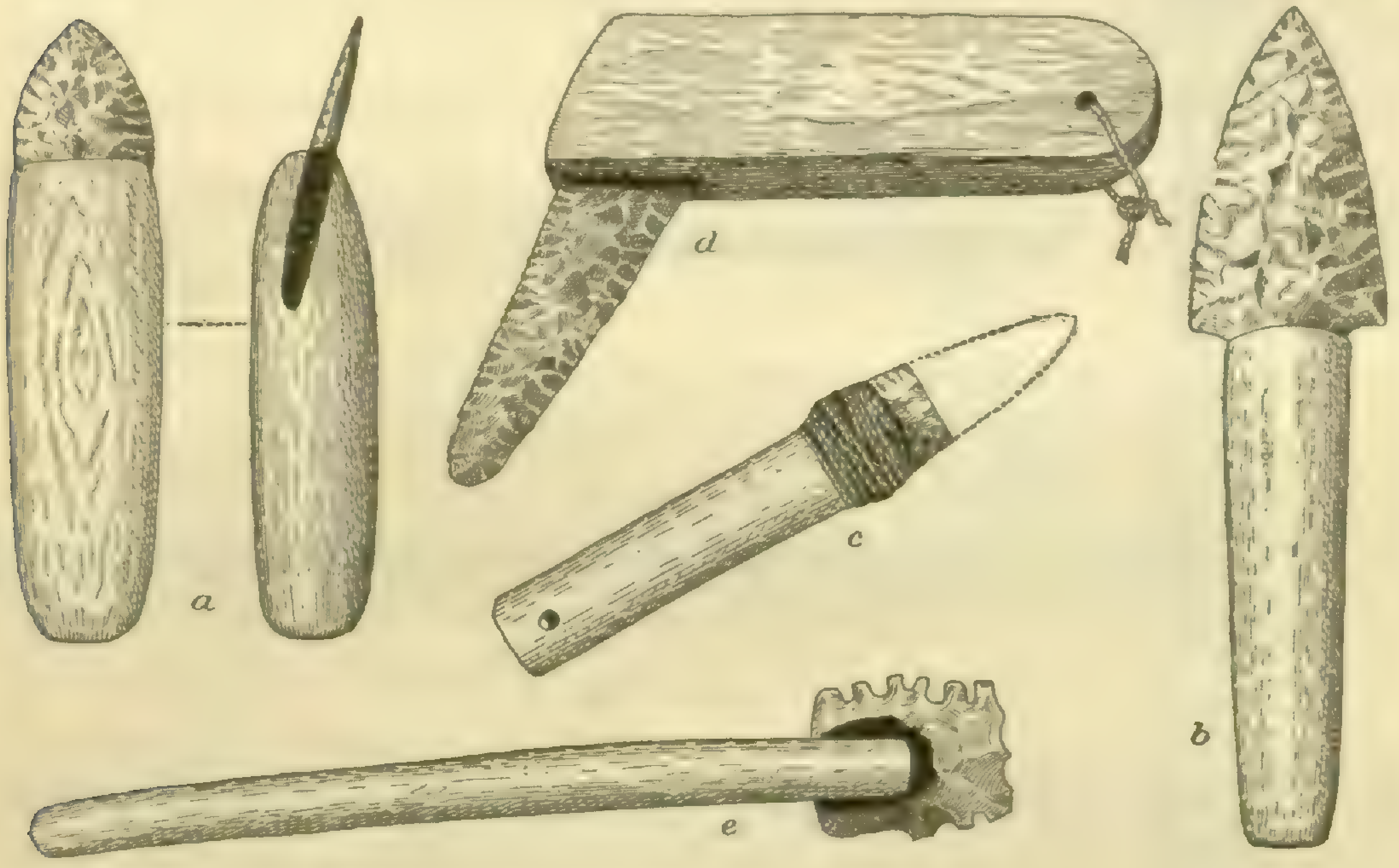

FIG. 2. — Prehistoric knives from the cliff houses, ½.

hafted in wooden handles. He is indebted to those in charge of the collections for permission to make the drawings accompanying this paper. Several of these knives are now in the Free Museum of Science and Art in Philadelphia.

The blades are chipped from different varieties of flint and chalcedony, and are of the common typical forms (leaf-shaped, triangular, stemmed, and notched) usually found in a collection of chipped implements. The handles are of wood, in most instances symmetrically fashioned and well finished, the blades being inserted into a deep notch and cemented with gum, probably of *Larrea mexicana*. In a few examples, windings of sinew or of cord made from yucca fiber furnish additional security.

The blades of the knives shown in Fig. 1 are attached to their handles with gum only. Their bases fit the notches snugly. The cement with which they are fastened projects slightly beyond the end of the haft and is pressed against the blade at either side. The blade of *a* is of black flint; *b* is also of dark flint, and *c* is chipped from gray chalcedony. A suspending cord of twisted cotton passes through the handle of *c*. The handle of *a* is also perforated for the passage of a cord.

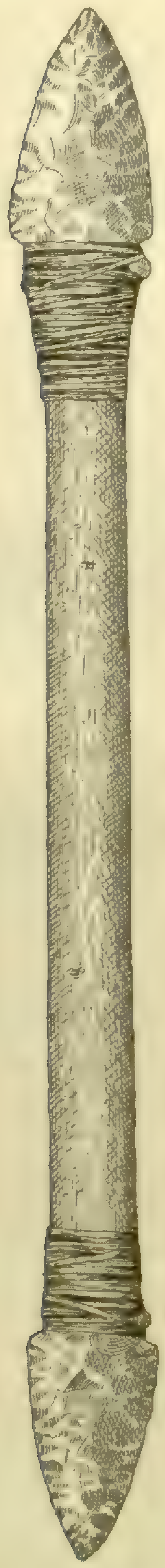

FIG. 3. — Prehistoric double-bladed knife from a cliff house, ½.

The leaf-shaped blade of the knife illustrated in Fig. 2, *a*, is of light-colored chalcedony and is inserted for about half its length into the wooden handle, being firmly secured with gum. The drawing shows both front and side.

The beautiful knife shown in Fig. 2, *b*, has a blade of the stemmed variety, chipped from pink chalcedony. It is attached to the wooden handle with gum only.

The broken blade of Fig. 2, *c*, is fastened with gum. As an additional security it is wrapped with a cord of twisted yucca fiber. The handle is perforated for the passage of a suspending cord.

The unique example illustrated at *d* has a blade of dark flint secured at an angle to the well-made wooden haft. A cord of twisted yucca fiber passes through a perforation near the end.

The implement represented in Fig. 2, *e*, would perhaps be most correctly classed as a saw. The blade is of a type widely distributed but nowhere common. It is chipped from dark flint. The teeth are thin and sharp, and in the hands of a skilled prehistoric workman it has doubtless done good execution in wood, bone, and antler. The handle is a section of a limb or shoot, and the blade is secured with gum.

The double-bladed knife illustrated in Fig. 3 has for a handle a section of a small sapling or limb, with the bark

still adhering. Its length, including the blades, is eleven and one-half inches. The notched blades are fastened with sinew. A similar double-bladed knife is shown in the hand of a god issuing from the mouth of a serpent sculptured upon one of the lintels of a ruined temple at Yaxchilan, southern Mexico.

It is very probable that the implements shown in Fig. 4 were primarily intended as foreshafts for light spears projected with a spear thrower, a few examples of this ingenious device having been found in the cliff houses of the Southwest. These spear throwers have double finger loops, and are in other respects very similar to the ancient Mexican atlatl used by both Mexicans and Mayas, and represented in their sculptures. The foreshafts of the spears accompanying the atlatl in the carvings resemble

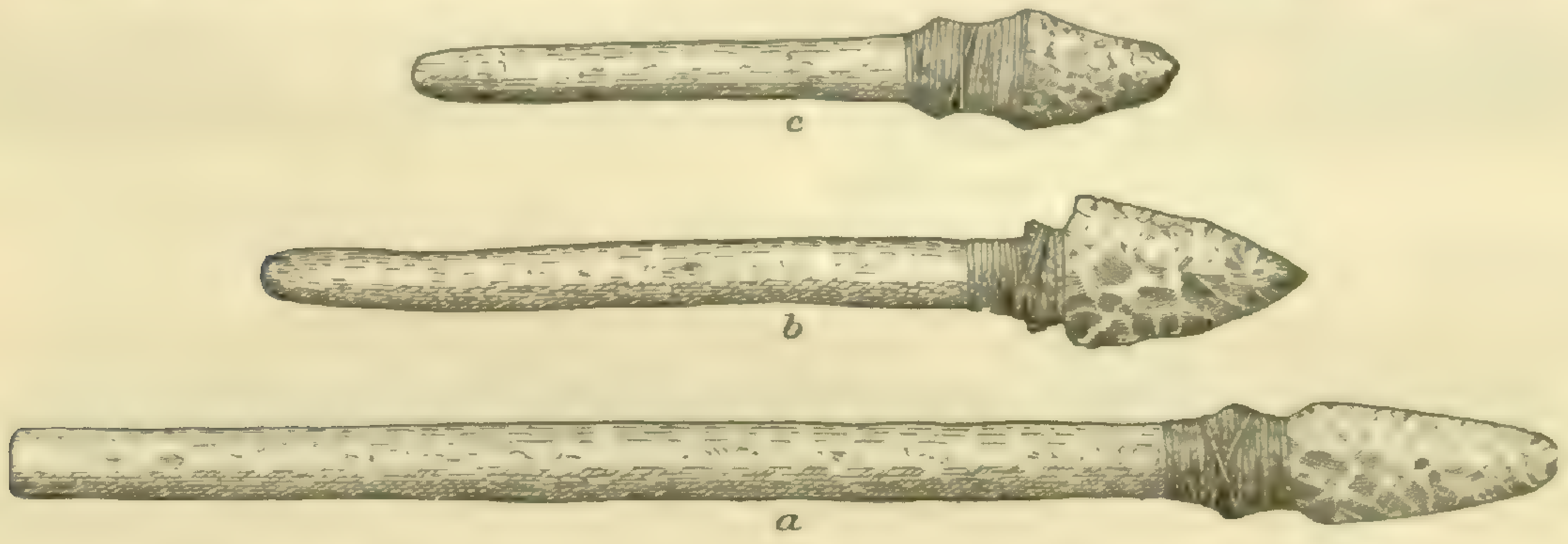

Fig. 4. — Prehistoric knives or foreshafts, ½.

those illustrated in Fig. 4. A foreshaft similar to Fig. 4, *b*, has the end opposite the point beveled for inserting into a socket at the end of the spear shaft. The lower end of Fig. 4, *c*, is also slightly beveled. The ends of *a* and *b* show no beveling, and these implements may have been intended for knives only; but if originally constructed for foreshafts to spears, it is probable, as they are detachable, that they were also used as cutting implements. The blades are secured to the hafts with sinew, no cement being visible.

In one of the collections was a spear-like implement tipped with a point of black flint closely resembling in form the knife blade illustrated in Fig. 1, *b*. This was secured in the notch with cement and cord wrappings. The shaft, forty inches in length, is worked smooth and polished, its lower end terminating in a rounding point.

Besides the tools whose functions are indicated by their forms, as perforators, scrapers, etc., chipped flint was used in America for cutting implements and as points for various kinds of projectiles, including arrows, light spears thrown with a throwing stick, harpoons with detachable heads, hand lances, small javelins, and thrusting weapons; but the greater number of flint implements of the common types, of lengths varying from about two inches to seven inches, were probably used as knife blades. Nor are we safe in assuming that the stemmed and notched forms were all projectile points, as an examination of Fig. 2, *b*, and Fig. 3 will show. It is of course impossible with our present knowledge to classify correctly all forms of chipped implements, but a study of the few prehistoric hafted examples known will materially aid us in the work.

PEABODY MUSEUM OF AMERICAN ARCHÆOLOGY AND ETHNOLOGY,
CAMBRIDGE, MASS.

ON THE AFFINITIES OF CERTAIN ANOMALOUS DICOTYLEDONS.

DOUGLAS HOUGHTON CAMPBELL.

THERE is still a difference of opinion among botanists as to the relationship between the two great divisions of angiospermous plants, monocotyledons and dicotyledons. The two groups have evidently been derived from a common stock, but which branch is the older is still somewhat doubtful.

Among the genera commonly referred to the dicotyledons are several which differ from the typical forms both in the structure of the flowers and in the character of the tissues, especially the structure and distribution of the vascular bundles. Among these anomalous dicotyledons may be mentioned the Nymphæaceæ, certain Ranunculaceæ (Actæa, Thalictrum), and among the Berberidaceæ, Podophyllum, Diphylleia, and Caulophyllum.

A recent paper[1] on the embryo of Nelumbo has called attention to the importance of a thorough study of these anomalous genera, whose embryogeny is almost completely unknown.

The result of Lyon's examination of Nelumbo was the discovery that the apparently dicotyledonous embryo has really but a single cotyledon and resembles that of the aquatic Alismales, an order of monocotyledons that shows numerous analogies with the Nymphæaceæ.

This interesting discovery suggested to the writer the advisability of looking up what had been already done with the study of the embryos of some of the other forms referred to, and although the results of these inquiries have been very incomplete, they have revealed a number of extremely suggestive facts, which are here given, and which emphasize the desirability of more thorough work in the same direction.

[1] Lyon, H. L. *Minnesota Botanical Studies*, Ser. 2, pt. v, 1901.

NYMPHÆACEÆ.

In several respects the Nymphæaceæ suggest the Alismales, rather than the dicotyledons, with which they are usually associated. Some of the earlier botanists, among them Jussieu, considered the Nymphæaceæ as true monocotyledons; but all later botanists have agreed in placing them with the Polycarpicæ, or Ranales, among the most primitive of the dicotyledons. The discovery that Nelumbo has a monocotyledonous embryo at once raises the question whether the other genera are also monocotyledonous. The structure of the flowers, especially in the simpler genera, Cabomba and Brasenia, is very much like that in some of the Alismales, and the character of the vascular bundles, as well as their arrangement in all the Nymphæaceæ, is similar to that in the typical monocotyledonous stem. The form of the leaves, also, is often very suggestive of the sagittate leaves of Alisma or Sagittaria. This is seen in Nuphar, especially when growing in shallow water, and the early leaves of other Nymphæaceæ (Fig. 1) are remarkably similar to those of Sagittaria. Whether or not this resemblance of the young leaves of these Nymphæaceæ to those of the Alismales is really an indication of relationship, it is worth noting in connection with the other points of resemblance.

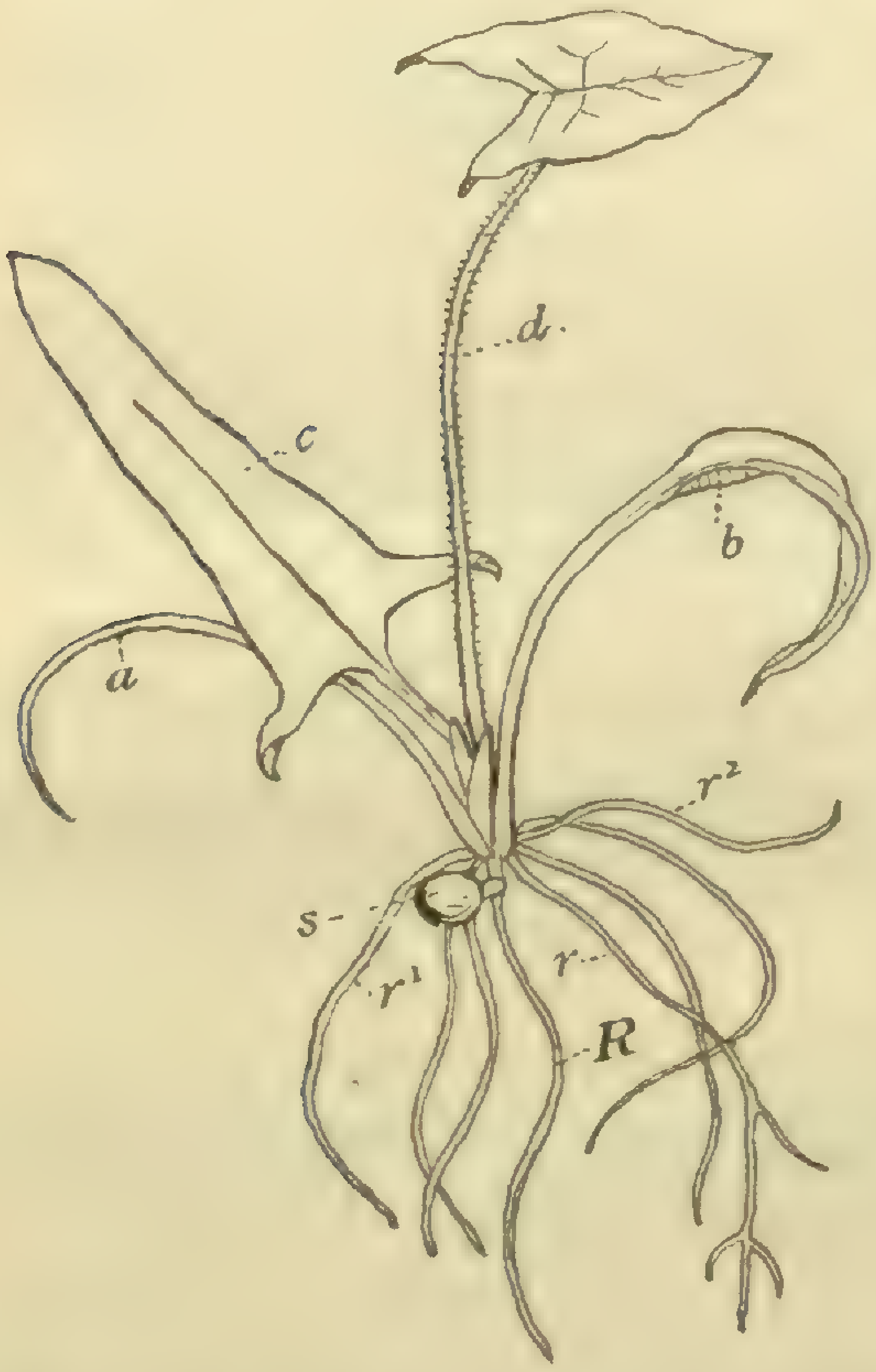

FIG. 1. — Seedling of *Victoria regia*, showing the sagittate form of the early leaves. (From Goebel, after Trécul.)

From Lyon's studies upon the embryo of Nelumbo it appears that in this genus the apparent two cotyledons are the result of a bifurcation of a single cotyledon. The stem apex arises laterally as in typical monocotyledons, and, as in these, the

cotyledon enwraps the plumule, which becomes largely developed. In Aponogeton, one of the Alismales, the sheathing base of the single cotyledon develops a pair of stipule-like lobes, which remotely suggest the two large lobes described for Nelumbo.

Whether the other Nymphæaceæ will show a monocotyledonous embryo remains to be seen, and the removal of the family to the Alismales is, perhaps, premature.

Ranunculaceæ.

A number of Ranunculaceæ resemble superficially the Alismales, especially as regards the structure of the flowers. The genus Echinodorus, of the Alismaceæ, for instance, has flowers closely resembling those of Ranunculus. Other Ranunculaceæ —*e.g.*, Actæa, Thalictrum—have the vascular bundles arranged much as in the typical monocotyledons instead of in the single ring characteristic of the typical dicotyledons.

Ranunculus ficaria has but a single cotyledon, which it is usually supposed is the result of the abortion of one of two cotyledons; but this has not been demonstrated, and it is barely possible it may prove to be truly monocotyledonous. Certain peculiarities in the embryos of other genera, which will be referred to later, point to the possibility of the embryo in these forms also having but a single cotyledon.

One important difference, however, must be noted between the Ranunculaceæ and the Alismales or Nymphæaceæ. In the two latter groups the embryo in the ripe seed is large, with very little endosperm about it. In the Ranunculaceæ the embryo in the ripe seed is always minute and is surrounded by abundant endosperm.

Anomalous Berberidaceæ.

Under the Berberidaceæ are generally included several peculiar genera of somewhat doubtful affinities. Of these, Jeffersonia, Podophyllum, and Diphylleia are especially interesting, as they are all small genera of peculiar distribution, being

represented in eastern Asia and Atlantic North America, but not occurring elsewhere. This points to their being old types which have persisted in these two widely separated regions, and adds to the interest in their history.

The development of the embryo is quite unknown in all of them, but the germination has been observed in Podophyllum, both in our native *P. peltatum* and in the Asiatic *P. emodi*, which agrees closely with *P. peltatum*.

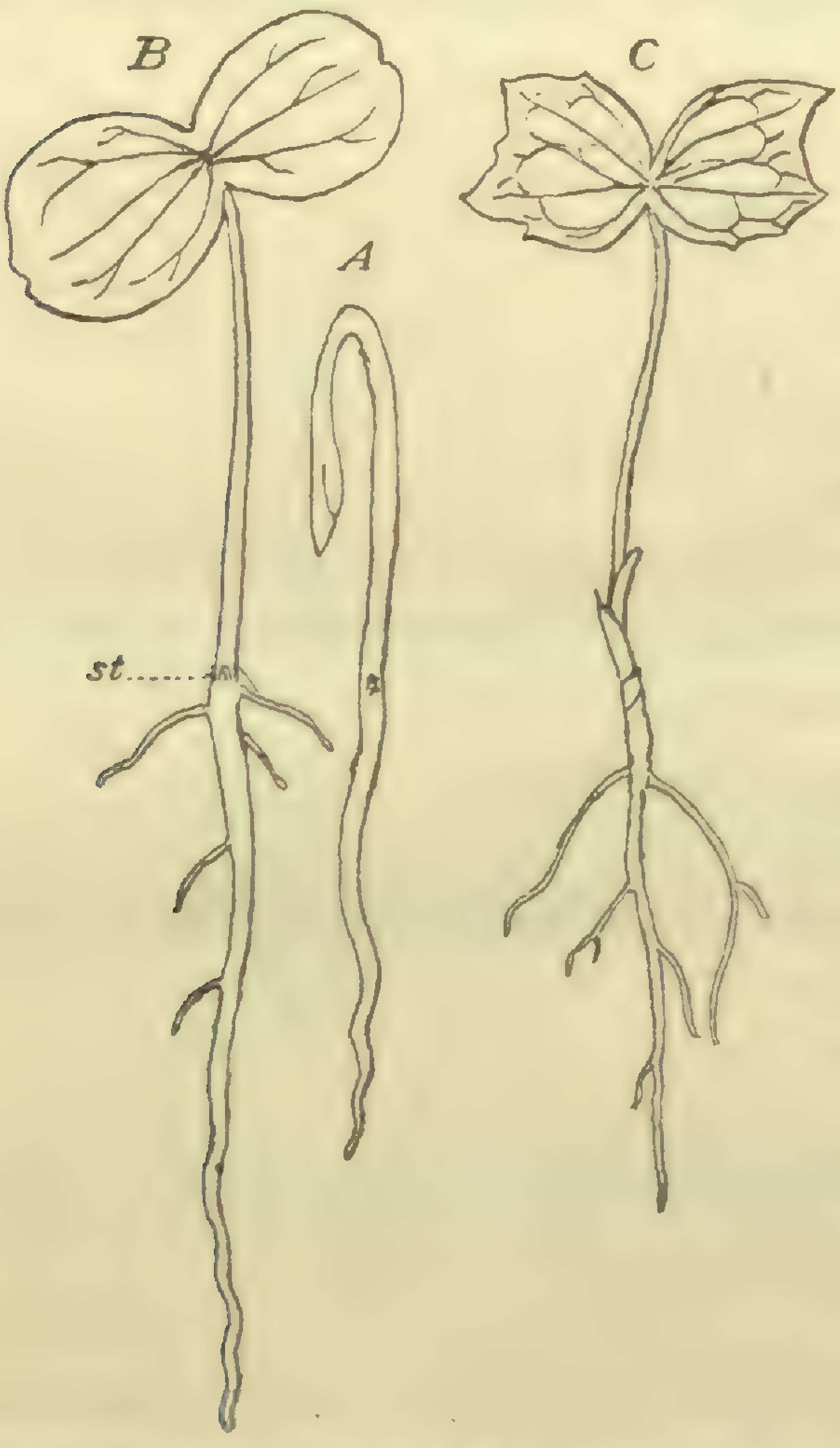

FIG. 2. — *A*, *B*, seedlings of *Podophyllum peltatum*, showing the coherent (?) cotyledons, and the plumule (*st*) at the base of the cotyledonary sheath. *C*, young plant in the second year; the binate leaf closely resembles the cotyledon. (After Holm.)

The latter species has been carefully studied by Holm,[1] and there are certain peculiarities in the germination, which, in view of the recent discovery in Nelumbo, are extremely significant. According to Holm (and the same is shown by Lubbock for *P. emodi*) there are apparently two cotyledons, with completely united, much elongated petioles, which form a hollow tube, at the base of which the plumule is placed (Fig. 2, *B*). The latter finally breaks through the base of the cotyledonary tube.

There would be nothing especially significant about this were it not found that the second leaf, as shown by Holm's studies, is deeply bilobed (Fig. 2, *C*) and resembles to an extraordinary degree the supposed *pair* of cotyledons. The thought was at once suggested, — Is not the supposed pair of cotyledons in Podophyllum really a single one, as in Nelumbo, the two apparent cotyledons being merely lobes of a single

[1] *Botanical Gazette*, 1899.

leaf? This view is much strengthened by the persistence of the bilobed form in the leaves of the young plant for several years, and the permanently binate leaves of the allied genera Jeffersonia and Diphylleia. The position of the plumule at the base of the cotyledonary tube suggests a possible lateral origin for this, as in typical monocotyledons and in Nelumbo. The character of the flowers and the tissues in Podophyllum and Diphylleia, as well as in Caulophyllum, are in accord with a possible monocotyledonous affinity for these forms. It is, at any rate, highly desirable that a careful embryological study should be made of these extremely peculiar plants.

The formation of a cotyledonary tube apparently similar to that in Podophyllum has been described for a number of widely separated forms, *e.g.*, Anemone, Delphinium, various Umbelliferæ, *Megarrhiza californica*, *Dodecatheon meadia*.[1] Whether in all of these there is really a coherence of two cotyledons must be determined by a study of the embryogeny.

It is evident that the last word has not yet been spoken as to the interrelationships of the angiosperms. The numerous studies upon the development of the embryo sac, which have appeared during the past few years, have shown that there is much more variation in the structures of the embryo sac than was supposed to be the case. The most marked departure from the angiospermous type is the genus Peperomia. The embryo sac of this genus has regularly sixteen nuclei instead of the eight usually present, and in this respect shows an approach to the condition obtaining among the gymnosperms and higher pteridophytes.

Peperomia, which appears to be genuinely dicotyledonous, nevertheless in the structure and distribution of the vascular bundles, as well as in the character and arrangement of the flowers, approaches some of the simpler monocotyledons, especially the Araceæ. It seems possible, as the writer has elsewhere suggested, that there may be two points where the two great divisions of angiosperms come together.

From the evidence at hand it would appear that the two phyla — monocotyledons and dicotyledons — are of about equal

[1] Holm, *loc cit.*, p. 422.

antiquity; but as a whole, the former have remained simpler than the dicotyledons. The scattered, closed vascular bundles probably represent a more primitive type of structure than the ring of open bundles characteristic of the more highly developed dicotyledons.

It is exceedingly important for a clear understanding of the affinities of such anomalous types as Podophyllum that a complete study should be made of the development of the embryo sac and embryo. Results of importance ought to reward the student who will make a critical study of the development of these puzzling forms.

Leland Stanford Jr. University.

THE SKELETON OF THE HEAD OF INSECTS.

JOHN HENRY COMSTOCK AND CHUJIRO KOCHI.

The skeleton of the head of an insect is composed of several sclerites more or less closely united, forming a capsule, which includes a portion of the viscera, and to which are articulated certain appendages.

The early entomologists, among whom were Fabricius (1775), Illiger (1800, 1806), Kirby (1802, 1826), Savigny (1816), Straus-Durckheim (1828), Burmeister (1832), Newman (1834), and Newport (1839), laid the foundation of our knowledge of the structure of this skeleton; and it is remarkable, considering the extent of entomological literature, how little has been added in this particular field since the publication of the article "Insecta" by the last-named writer.

Although comparatively little progress has been made in the study of the sclerites of the head during the last sixty years, very much has been learned by the workers of to-day regarding the development of this region of the body; and the time has come when, using the known facts of embryology as a starting point, one can hope, by comparative anatomical studies, to gain a clearer idea of the structure of the skeleton of the head than has been set forth as yet. To do this has been the aim of the writers of this paper.

The Areas of the External Skeleton.

In descriptions of insects it is necessary to refer to the different regions of the surface of the head. This has resulted in the establishment of a nomenclature, which, although based on the work of the early insect anatomists, is really of comparatively little morphological value; for but few of the primitive sclerites of the head have remained distinct, and some of them greatly overshadow others in their development. The result

is that in some cases a named area includes several sclerites, while in other cases only a portion of a sclerite is included.

This nomenclature, however, is sufficient for the needs of describers of species, and will doubtless continue in use. It is worth while, therefore, to review it briefly and to attempt where necessary to make it more definite.

FIG. 1. — Head of a cricket.

The best landmark from which to start for this purpose is the *epicranial suture*, the inverted Y-shaped suture on the dorsal part of the head, in the more generalized insects (Fig. 1, *e.su.*). Behind the arms of this Y there is a series of *paired* sclerites, which meet on the middle line of the dorsal wall of the head, the line of union being the stem of the Y; and between the arms of the Y and the mouth there are typically three *single* sclerites (Fig. 1, *F, C, L*). It is with these unpaired sclerites that we will begin our definitions of the areas of the head.

The Front (*frons*, Kirby; *clypeus posterior*, Newport). — The unpaired sclerite between the arms of the epicranial suture (Fig. 1, *F*).

In the more generalized insects at least, if not in all, the front bears the median ocellus; and in the Plecoptera, the paired ocelli also. Frequently the suture between the front and the following sclerite, the clypeus, is obsolete; but as it ends on each side in the invagination which forms the anterior arms of the tentorium (Fig. 2, *at*), its former position can be inferred, at least in the more generalized insects, even when no other trace of it remains. In Fig. 2 this is indicated by a dotted line.

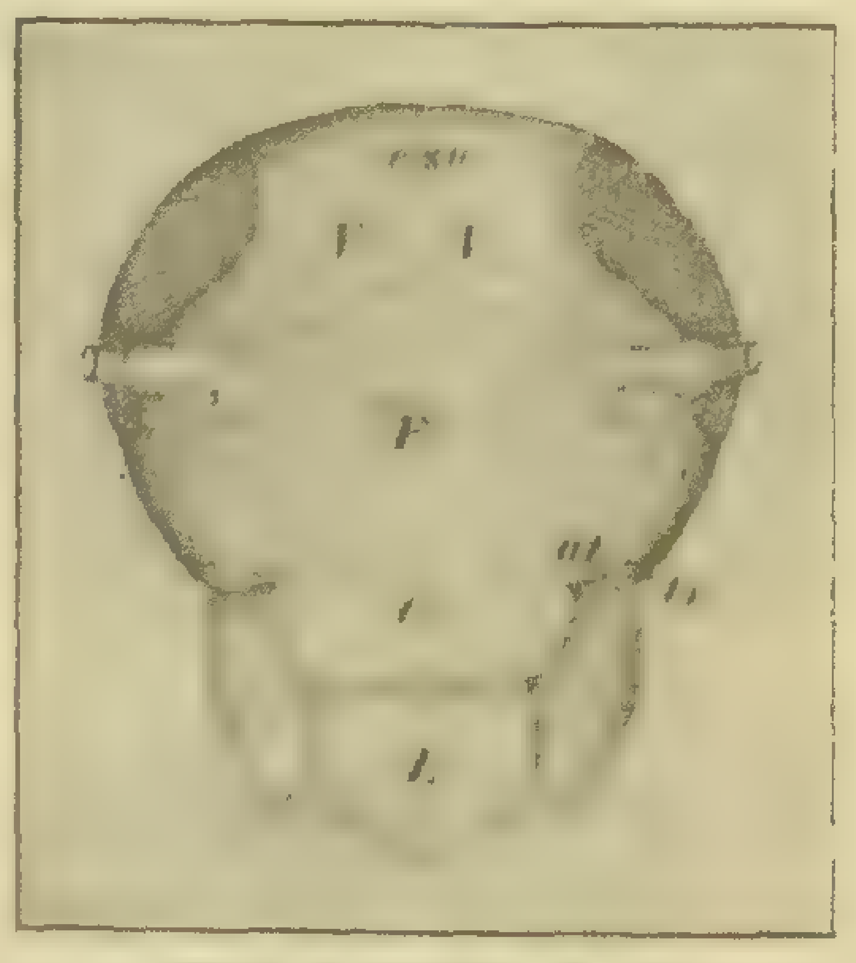

FIG. 2. — Head of a cockroach.

The Clypeus (*clypeus*, Fabricius; *chaperon*, Straus-Durckheim; *clypeus anterior*, Newport). — The intermediate of the three unpaired sclerites between the epicranial suture and the mouth (Fig. 1, *C*). To this part one condyle (the ventral) of the mandible articulates.

Although the clypeus almost always appears to be a single sclerite, except when divided transversely as indicated below, it really consists of a transverse row of three sclerites, — one on the median line and one on each side articulating with the mandible. The median sclerite may be designated the *clypeus proper*, and each lateral sclerite, the *antecoxal piece of the mandible.* Usually there are no indications of the sutures separating the clypeus proper from the antecoxal pieces; but in some insects they are distinct. In the larva of Corydalis the antecoxal pieces are not only distinct but are quite large (Fig. 3, *ac, ac*).

Fig. 3. — Head of the larva of Corydalis, dorsal aspect.

In some insects the clypeus is completely or partly divided by a transverse suture into two parts (Fig. 1). These may be designated as the *first clypeus* and the *second clypeus*, respectively; the first clypeus being the part next the front (Fig. 1, C_1) and the second clypeus being that next the labrum (Fig. 1, C_2).

There is a great lack of uniformity in the application of the term *clypeus*, arising from the fact that many writers apply it to the entire area between the epicranial suture and the labrum; either overlooking the fact that the part here designated as the front is a distinct sclerite, or, following Newport, terming it the *clypeus posterior.* But as the front and the clypeus (in the more restricted sense) pertain to different segments of the head, it is desirable to use distinct names for them; and as the names proposed by Newport are morphologically incorrect, the so-called clypeus posterior being in front of the so-called clypeus anterior, as will be shown later, it is doubtless better to use the older term *frons*, or *front*, for the sclerite next the epicranial suture, and to restrict the term *clypeus* to the part termed *clypeus anterior* by Newport.

The Labrum (*labrum*, Illiger). — A movable flap which constitutes the upper lip of the mouth (Fig. 1, *L*). The labrum is the last of the series of unpaired sclerites between the

epicranial suture and the mouth. It has the appearance of an appendage but is really a portion of one of the head segments.

The Epicranium (*épicrâne*, Straus-Durckheim). — Under this term are included all of the paired sclerites of the skull, and sometimes also the front. The paired sclerites constitute the sides of the head and that portion of the dorsal surface that is behind the arms of the epicranial suture. The sclerites constituting this region are so closely united that they were regarded as a single piece by Straus-Durckheim, who also included the front in this region, the epicranial suture being obsolete in the May beetle, which he used as a type.

The Vertex (*vertex*, Kirby). — The dorsal portion of the epicranium; or, more specifically, that portion which is next the front and between the compound eyes (Fig. 1, *V, V*). In many insects the vertex bears the paired ocelli. It is not a definite sclerite; but the term *vertex* is a very useful one and will doubtless be retained.

The Occiput (*occiput*, Kirby). — The hind part of the dorsal surface of the head. When a distinct sclerite, it is formed from the tergal portion of the united postgenæ described below (Fig. 3, *O, O*).

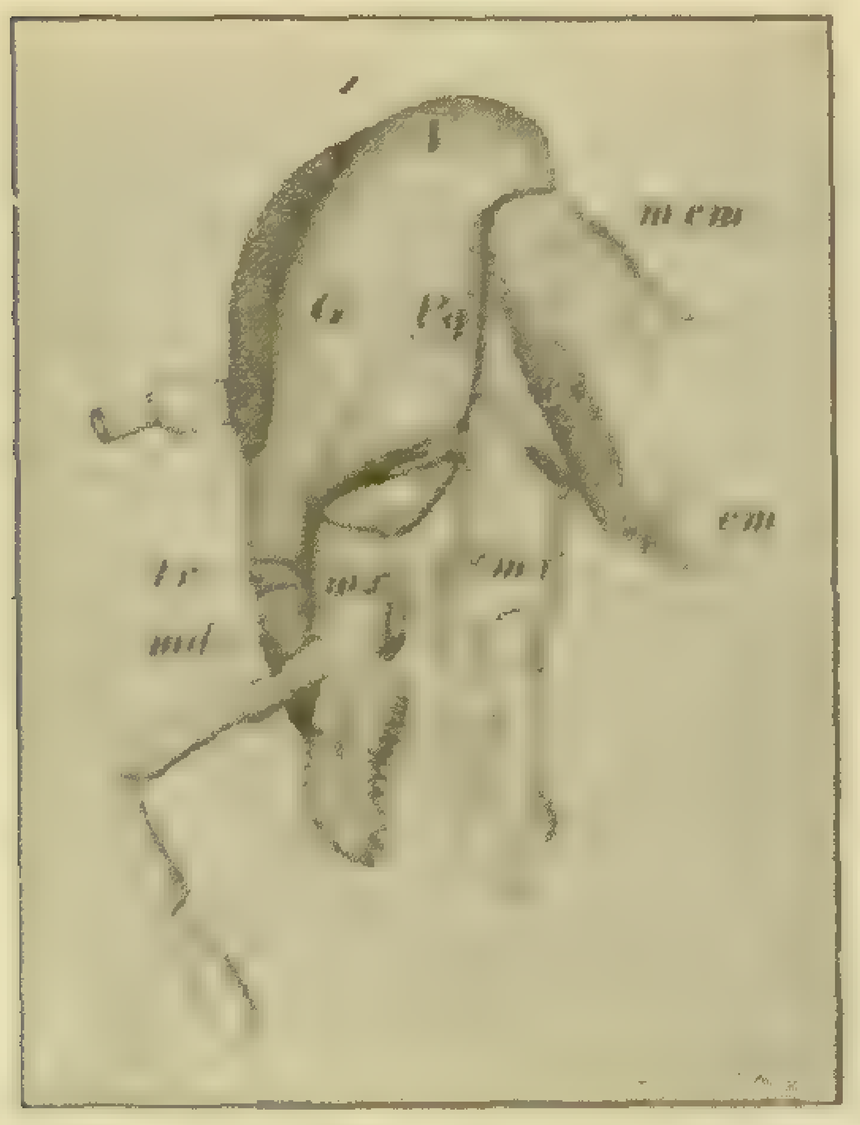

FIG. 4. — Head and neck of a cockroach.

The Genæ (*genæ*, Kirby). — The lateral portions of the epicranium. Each gena, in the sense in which the word was used by the older writers, includes a portion of several sclerites. Like *vertex*, however, the term is a useful one.

The Postgenæ. — In many insects each gena is divided by a well-marked suture. This led Comstock[1] to restrict the term *gena* to the part in front of the suture (Fig. 4, *G*), and to propose the term *postgenæ* for the part behind the suture (Fig. 4, *Pg*).

The Gula (*gula*, Kirby; *pièce basilaire*, Straus-Durckheim). — A sclerite forming the ventral wall of the hind part of the head in certain orders of insects, and bearing the labium or second

[1] Comstock and Kellogg. *Elements of Insect Anatomy*. 1895.

maxillæ (Fig. 5, *Gu*). In the more generalized orders, the sclerite corresponding to the gula does not form a part of the skull.

The Cervical Sclerites (*cervical sclerites,* Huxley). — Small sclerites found in the neck of many insects. Of these there are dorsal, lateral, and ventral sclerites; the lateral cervical sclerites have been termed the *jugular sclerites* (*pièces jugulaires,* Straus-Durckheim) (Fig. 4, *es, em*).

Other Sclerites. — In addition to the areas and sclerites named above, the following sclerites will be described in later pages of this essay: the *ocular sclerite,* the *antennal sclerite,* the *trochantin of the mandible,* and the *maxillary pleurites.* These terms should be added to the list of those available for the purposes of systematic entomology.

Fig. 5. — Head of Corydalis, adult, ventral aspect.

The Segments of the Head.

The determination of the number of segments in the head of an insect is a problem that has been much discussed since the early days of entomology. The first important step towards its solution was made by Savigny (1816), who suggested that the movable appendages of the head were homodynamous with legs. This conclusion has been accepted by all; and as each segment in the body of an insect bears only a single pair of appendages, there are at least four segments in the head; *i.e.*, the antennal, the mandibular, the maxillary, and the second maxillary or labial.

As the compound eyes are borne on movable stalks in certain Crustacea, it was held by Milne-Edwards that they represent another pair of appendages; but this view has not been generally accepted. It is not necessary, however, to discuss in this place whether the eyes represent appendages or not; the existence of an ocular segment has been demonstrated in another way, to be discussed later.

This is the point to which the solution of the problem was carried by the methods of comparative anatomy. The existence

of four segments was demonstrated, and the presence of a fifth (the ocular) suggested. From this point the work has been carried on chiefly by the embryologists.

Fig. 6. — Embryo of a damsel fly (Calopteryx), after Brandt.

The existence in the embryo of distinct segments, each corresponding to a pair of mouth parts, was early shown. Among the better of the older figures for this purpose are those of Brandt (**'69**, Fig. 12) and of Packard (**'71**). Fig. 6, which is copied from Brandt, represents an early stage in the development of the embryo of a damsel fly (Calopteryx). In this stage the labial and maxillary segments are quite distinct, appearing to be body segments rather than cephalic. This doubtless represents a phylogenetic stage, in which the head proper consisted of fewer segments than it does in existing insects.

It was also found that the subœsophageal ganglion, which innervates the mandibles, maxillæ, and labium, is formed by the union of at least three pairs of primitive ganglia. Fig. 7, from Heider (**'89**), represents a stage in the development of Hydrophilus, in which these ganglia are still distinct, each pair of ganglia corresponding to a pair of mouth parts.

Fig. 7. — Embryo of Hydrophilus, after Heider.

So far the results of embryology merely confirm the conclusions of comparative anatomy. But the embryologists have also demonstrated the existence of vestiges of segments, which had not been recognized as such by the early writers.

In his work on the embryology of the honeybee, Bütschli (**'70**) described a pair of evanescent appendages situated between the antennæ and the mandibles. Later these were observed by others, and writers began to refer to a "premandibular," or "intercalary," segment in the head of insects. More recently the appendages of this vestigial segment, which is properly termed the second antennal segment, were observed in the embryo of Anurida by Wheeler (**'93**) and by Claypole (**'98**).

They were also observed in Campodea by Uzel ('**97**). The last writer states that these appendages persist in the adult Campodea, and Folsom ('**99b**) says, "I may add that rudimentary chitinized intercalary appendages persist in adults of Tomocerus, Orchesella, and other Collembola."

Equally important evidence as to the existence of a second antennal segment in insects has been furnished by studies of the nervous system. It was shown by Viallanes ('**87a**) in his study of the structure of the brain (supra-œsophageal ganglion) of Vespa that there are three principal divisions in the brain of insects. These he named the *protocerebrum*, the *deutocerebrum*, and the *tritocerebrum*. Almost immediately after Patten ('**88**) demonstrated that the brain is formed from three pairs of primary ganglia; and the same fact was shown by Wheeler ('**89**). Viallanes also showed that the protocerebrum innervates the compound eyes and ocelli; the deutocerebrum, the antennae; and the tritocerebrum, the labrum. This demonstrates the existence of three premandibular segments: first, an ocular or protocerebral segment, without appendages, unless the compound eyes represent them (the supposed discovery of other appendages on the ocular segment by Carriere ('**90**) has not been confirmed); second, an antennal or deutocerebral segment, bearing antennæ; and third, a second antennal, or tritocerebral segment, of which the labrum is a part, and to which the so-called intercalary appendages doubtless belong. As Viallanes has shown that the tritocerebrum of Crustacea innervates the second antennæ, we are warranted in considering the tritocerebral segment of insects to be the second antennal segment.

The evidence thus far brought forward demonstrates the existence of six cephalic segments, — three innervated by the brain and three by the subœsophageal ganglion. We have now to refer to the evidence indicating the existence of a seventh cephalic segment.

The hypopharynx of insects is usually, in the Pterygota, a tongue-like organ lying below and projecting in front of the beginning of the alimentary canal. In the Apterygota it consists of three distinct parts, — a median organ termed th

"lingua" and a pair of organs termed "paraglossæ" by writers on the Thysanura and Collembola. As the term "paraglossæ" has long been used for a part of the labium or second maxillæ, Folsom ('00) justly maintains that it should not be applied to a part of the hypopharynx, and proposes for these paired organs the term *superlinguæ*.

FIG. 8. — Head of embryo of Anurida, after Folsom.

In his work on the development of apterygote insects, Uzel ('98) showed that the lingua arises between the rudiments of the maxillæ; hence it may be regarded as pertaining to the sternum of the maxillary segment. Uzel also showed that the superlinguæ arise as a pair of appendages between the mandibles and the maxillæ. This indicates the existence of a segment between the mandibular and the maxillary segments.

Similar results were obtained by Folsom ('00) in his work on the development of the mouth parts of Anurida. Fig. 8 is copied from Folsom and illustrates the relative positions of the rudiments of the mouth parts. To Folsom also belongs the credit of completing the evidence of the existence of a superlingual segment, by demonstrating the existence of a pair of primary ganglia between those of the mandibular and of the maxillary segments (Fig. 9, *5*). And in a preliminary paper ('99b), he set forth the first complete account of what promises to be our final view regarding the segmentation of the head.

FIG. 9. — Section of the head of an embryo of Anurida, after Folsom.

In confirmation of the view that the subœsophageal ganglion consists of four pairs of primary ganglia, it should be mentioned that long ago Patten ('88) figured these ganglia. It has been believed, however, that

the pair immediately in front of the maxillary ganglia were the mandibular ganglia (see Korschelt and Heider, '99b, p. 326); but it is more probable that the first of these four pairs of ganglia (Fig. 10, *4*) pertains to the mandibular segment and that the second pair are the homologues of the superlingual ganglia figured by Folsom.

Fig. 10. — Head of embryo of Acilius, after Patten.

The seven segments of the head are designated as follows:

First, ocular, or protocerebral.
Second, antennal, or deutocerebral.
Third, second antennal, or tritocerebral.
Fourth, mandibular.
Fifth, superlingual.
Sixth, maxillary.
Seventh, labial, or second maxillary.

Diagrams of the Elements of the Head.

The head of an insect consists of seven segments closely consolidated, greatly reduced in length, and, in the case of some, bent out of the original line. The morphological relations of these segments can be shown by representing them as distinct, of uniform size, and in a direct line. This is done in the accompanying diagram (Fig. 11, *A*).

Let us trace the steps by which this diagram was made. First, the outlines of the seven segments were drawn as if no

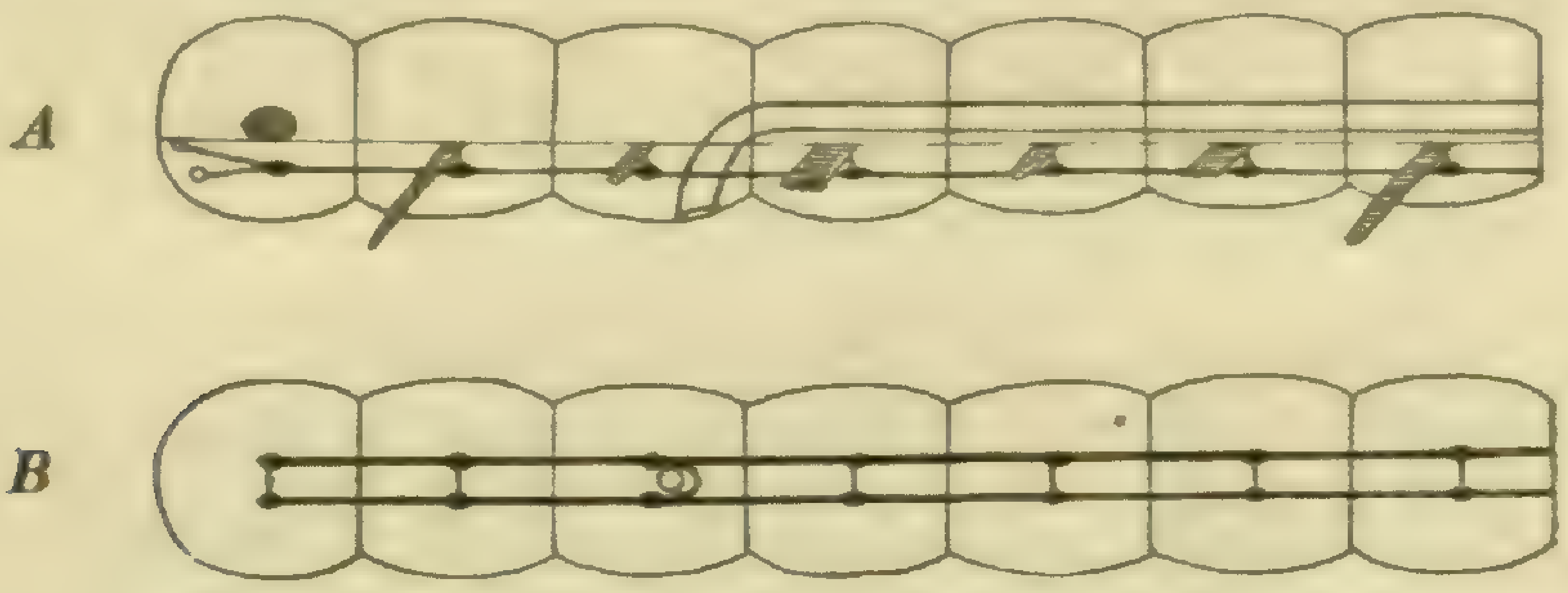

Fig. 11. — Diagrams of the elements of the head: *A*, lateral aspect; *B*, ventral aspect.

reduction or consolidation of any of them had occurred; at this stage the diagram might represent the cephalic end of an earthworm, except that the prostomium is not represented.

Second, a longitudinal line was drawn representing the line of separation of the sternal from the pleural elements of the segments; it is along this line that the appendages are borne. Third, the chain of ganglia were added, a pair of ganglia in each segment; as the nervous system is developed from the ectoderm on the ventral side of the body between the appendages, it is represented in the sternal portion of the preoral segments as well as in the postoral segments. The diagram being of a side view, only a single member of each pair of ganglia and longitudinal commissures are shown. Fig. 11, *B*, is a diagrammatic representation of a ventral view of the nervous system. Fourth, the compound eyes and the ocelli were represented in the first segment (Fig. 11, *A*), because they are innervated by the protocerebrum. The reasons for the exact positions within the segment assigned to these organs will be discussed later. Fifth, the position of the appendages was indicated, a pair to each segment except the first. It will be remembered that the antennæ are innervated by the deutocerebrum; hence they pertain to the second segment. Sixth, the mouth was represented as opening in the ventral wall of the third segment; this is in accordance with the results of the studies of Viallanes (**'87a**), who has shown that, although the third pair of ganglia enter into the composition of the supra-œsophageal ganglion, the commissure which connects them passes behind the œsophagus. This is shown in the second diagram. Although the position assigned to the mouth in these diagrams was suggested by the results of the studies of Viallanes, it is not in accordance with his conclusions; for he evidently believes that the mouth opens between the third and fourth segments.[1] Our view is based on the well-known fact that the mouth of the embryo is formed *in* the labral rudiment and not behind it.

The determination of the position of the mouth is one of the most striking of the results of the later studies of the head. Naturally the older entomologists believed that the mouth-opening was at the cephalic end of the body, and this effectually

[1] "La tête de l'insecte est formée par six zoonites; trois sont prebuccaux et trois post-buccaux." — Villanes (**'87b**, p. 117).

prevented a correct homologizing of the sclerites of the head. It is evident that the old belief is still held by many; thus Heymons (**'95**) designates what he believes to be the first segment the *primäres Kopfsegment oder Oralstück.*

The earliest suggestion of a different position of the mouth that we have met was by E. Ray Lancaster (**'73**), who refers to an "adaptational shifting of the oral aperture." The later writings contain many references bearing upon this, although the full force of them is evidently not appreciated by the writers. Thus it has been said by many that although the antennæ were doubtless originally postoral they have become preoral. The facts would be more accurately stated by saying that although the mouth was doubtless originally preantennal it has become postantennal. This, however, would only partially indicate the change that has taken place; for, as will be shown later, the antennæ have moved cephalad at the same time that the mouth has moved caudad.

The Structure of a Typical Segment.

In order to determine the homologies of the sclerites of the head, it is necessary to decide what sclerites were probably present before the consolidation and reduction of its segments took place. We have decided that the head is composed of seven segments; let us now determine the elements in the skeleton of a single segment. This necessitates a study of segments in other regions of the body.

In the abdomen it is evident that a reduction of certain parts has taken place, correlated with the loss of the abdominal appendages; it is to the thorax, therefore, that we must look for the more typical insectean segment.

The parts of a thoracic segment that are commonly recognized are those described by Audouin (**'24**): a ventral part, *sternite;* two lateral parts, *pleurites;* and a dorsal part, *tergite.*

These are most easily seen in the wing-bearing segments; but they can be recognized also in the prothorax of certain generalized insects. This is especially the case in many Orthoptera, as cockroaches and walking-sticks, where the

pleurites of the prothorax are distinct from the sternum on the one hand and from the tergum on the other; more often, however, the tergite of the prothorax is not separated from the pleurites. This is also the case in the segments of the head: sometimes the tergite is distinct from the pleurites; but more often the tergite is merely a continuation of the pleurites over the dorsal side of the segment. In such cases the combined lateral and dorsal parts are designated as the pleurites; for we find that they bear the most characteristic feature of the pleurites, the lateral apodemes, to be described later.

FIG. 12. — Ventral aspect of the metathorax of a nymph of Pteronarcys.

Equally important for the purposes of this study is the fact that each thoracic segment is composed of two subsegments. It is not necessary for us to decide in this place whether or not this indicates a fusion between two primary metameres, as has been suggested by various writers [1]; the essential fact which must be taken into account is the transverse division of each segment. The line separating the subsegments passes, on the pleural aspect, between the episternum and the epimeron; and, on the tergal aspect, between the scutum and the scutellum. On the sternal aspect, in most insects, the division is not easily recognized; but in certain Plecoptera and Orthoptera it can be readily seen.

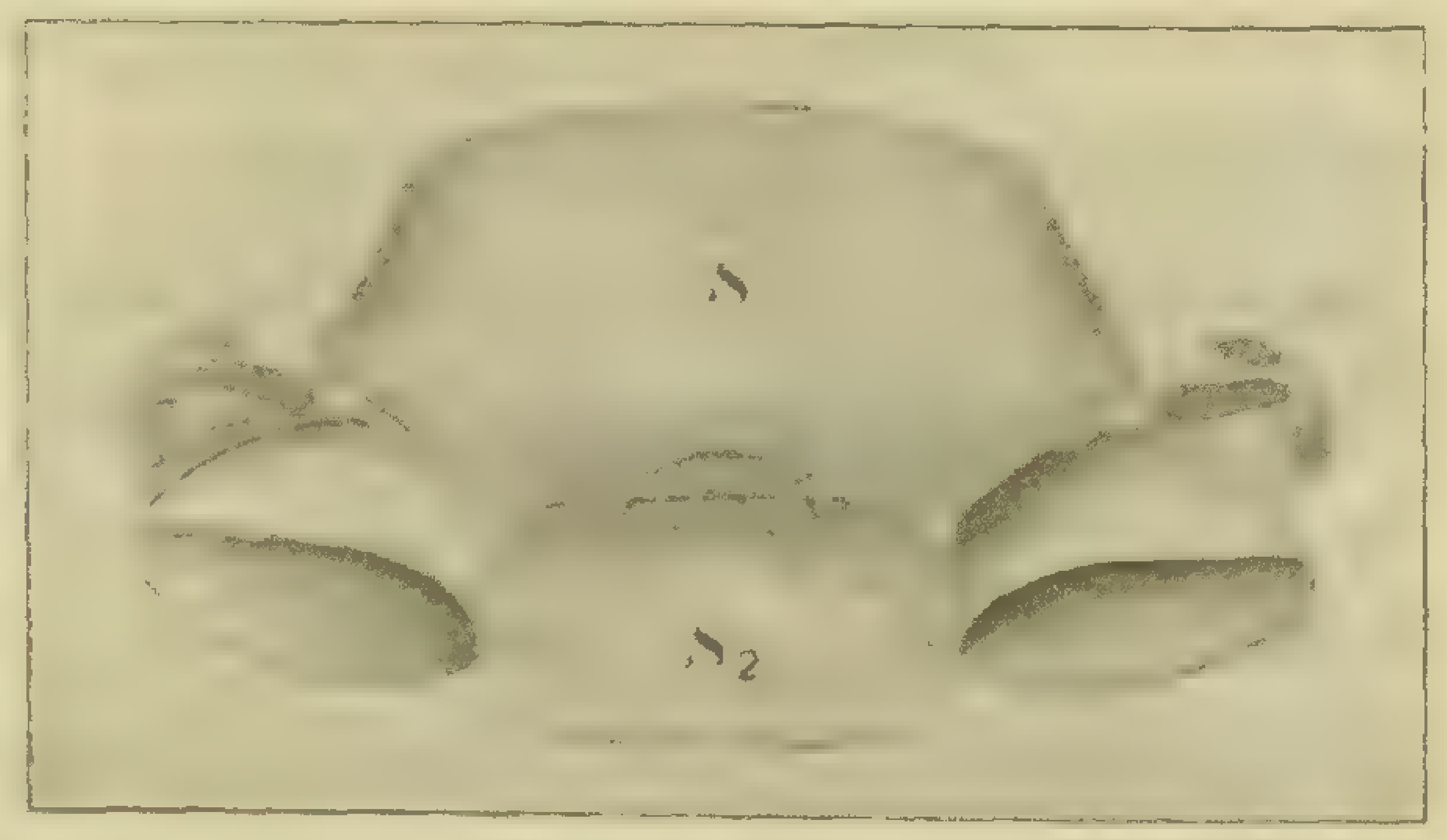

FIG. 13.—Ventral aspect of the metathorax of Stenopelmatus. The position of the furca within the body is represented by a dotted line.

Fig. 12 represents the sternite of the metathorax of a nymph of Pteronarcys, and Fig. 13 the same part of Stenopelmatus. In each case it can be seen that the sternite is composed of two distinct sclerites, — one lying between the episterna and one

[1] The reasons for believing that each segment is composed of two primary metameres have been well stated by Patten ('90, pp. 319, 320).

between the coxæ; the former pertains to the first subsegment, the latter, to the second.

In the furrow or suture between these two sclerites are the invaginations forming the furca of that segment. The position of the furca is, therefore, a good landmark for determining the line of union of the two sclerites forming a sternite, or, in other words, the division between the subsegments.

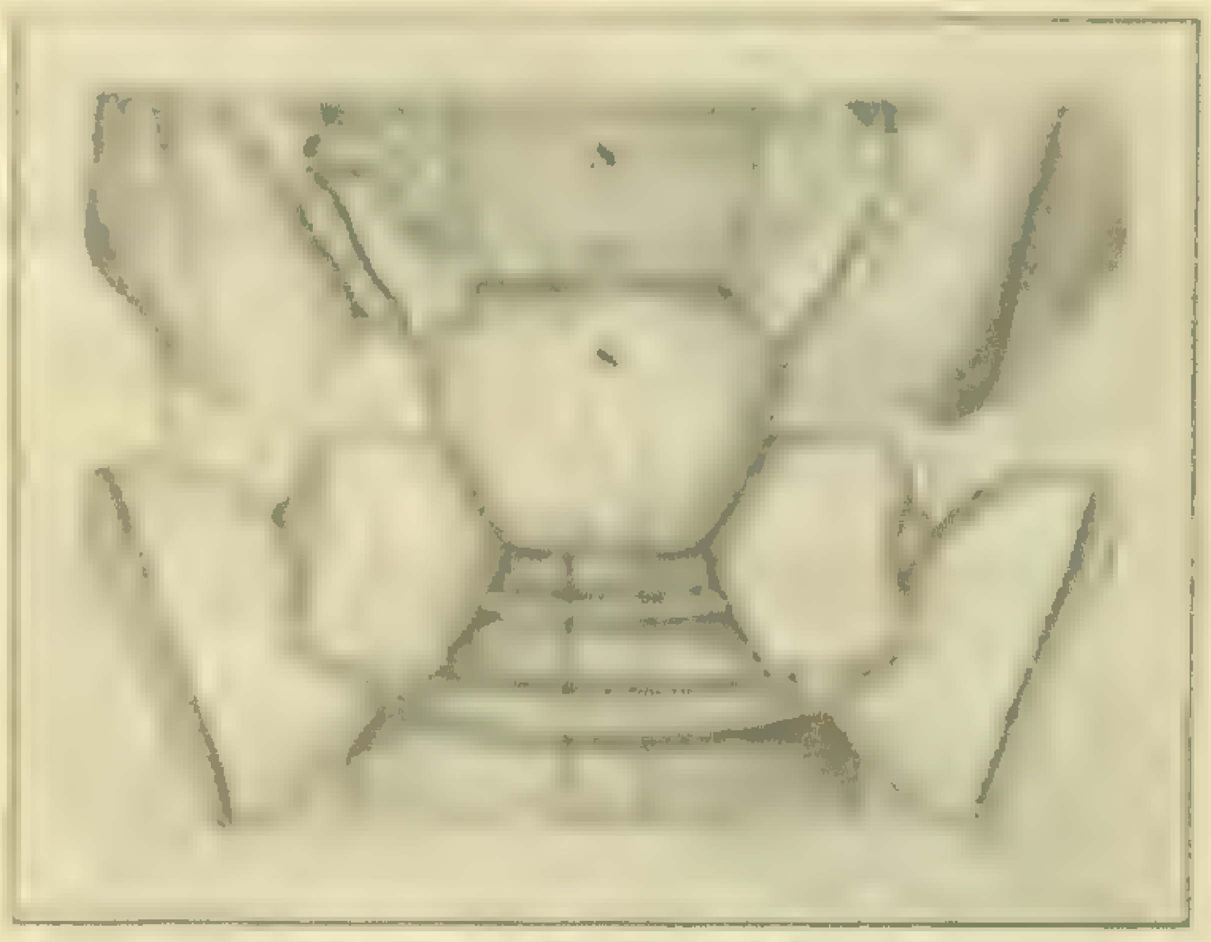

Fig. 14. — Ventral aspect of the meso- and metathorax of Gryllus; the positions of the furcæ within the body are indicated by dotted lines.

The second of the sclerites forming a sternite is smaller than the first, even in those insects where it is best developed; and in most insects it is greatly reduced or obsolete, so that the furca appears to arise from the caudal margin of the segment (Fig. 14). It is for this reason that the sternite of the second subsegment has been overlooked heretofore. The sternite of the first subsegment is retained in all insects, and is the sclerite to which the term *sternum* has been universally applied. The smaller sternite of the second subsegment may be termed the ***sternellum*** (Fig. 12, S_2; Fig. 13, S_2).

Sometimes, as in Pteronarcys, the cephalic portion of the sternum is more or less separate from the main part; this detached portion may be termed the ***præsternum*** (Fig. 12, *prs*). A ***poststernellum***, corresponding to the postscutellum, has not been observed.

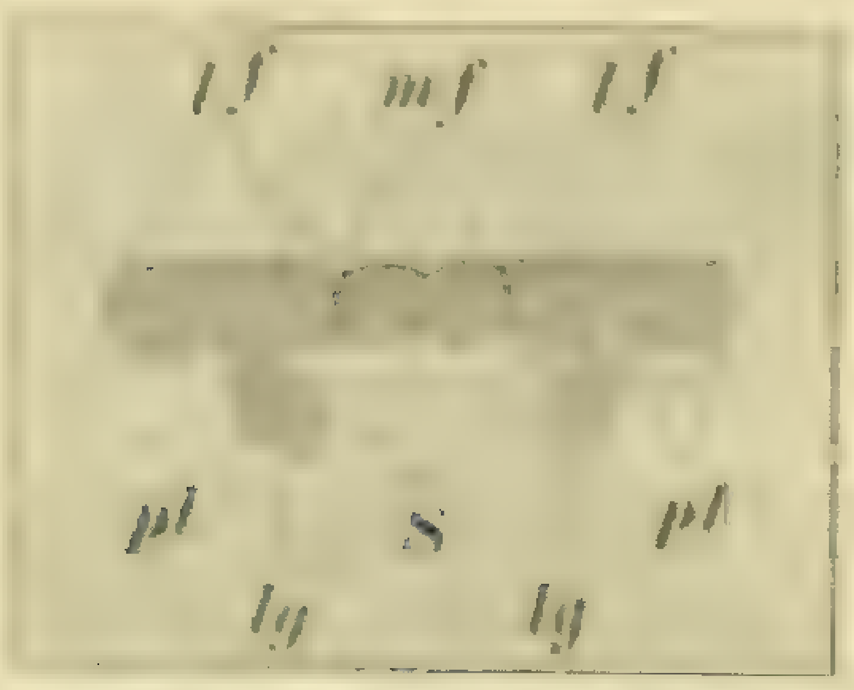

Fig. 15. — Diagram of a segment of an embryo, after Heymons.

It has been shown by Haase ('89) and Heymons ('95) that in a comparatively early embryonic stage each segment of the body is composed of three parts, — a median field and two lateral fields (Fig. 15), — and that the appendages are developed as evaginations of the lateral fields. Each sternite is therefore composed of three parts, — the portion derived from the median field of the segment, and, on each side, a portion derived from that part of the lateral field which lies

between the appendage and the median field. This portion may be designated the *lateral element of the sternite.* Such a division is well shown in the abdominal sternites of the adult Gryllus (Fig. 14).

More frequently, however, when a sternum in an adult insect is divided longitudinally it is by a single median suture, which perhaps represents the neural groove of the embryo.

A sternite of a subsegment may be composed, therefore, of either two or three elements : in the one case the sutures between the median field and the lateral fields are preserved ; in the other, a trace of the neural groove is indicated. But as a rule, each sternite is an undivided sclerite.

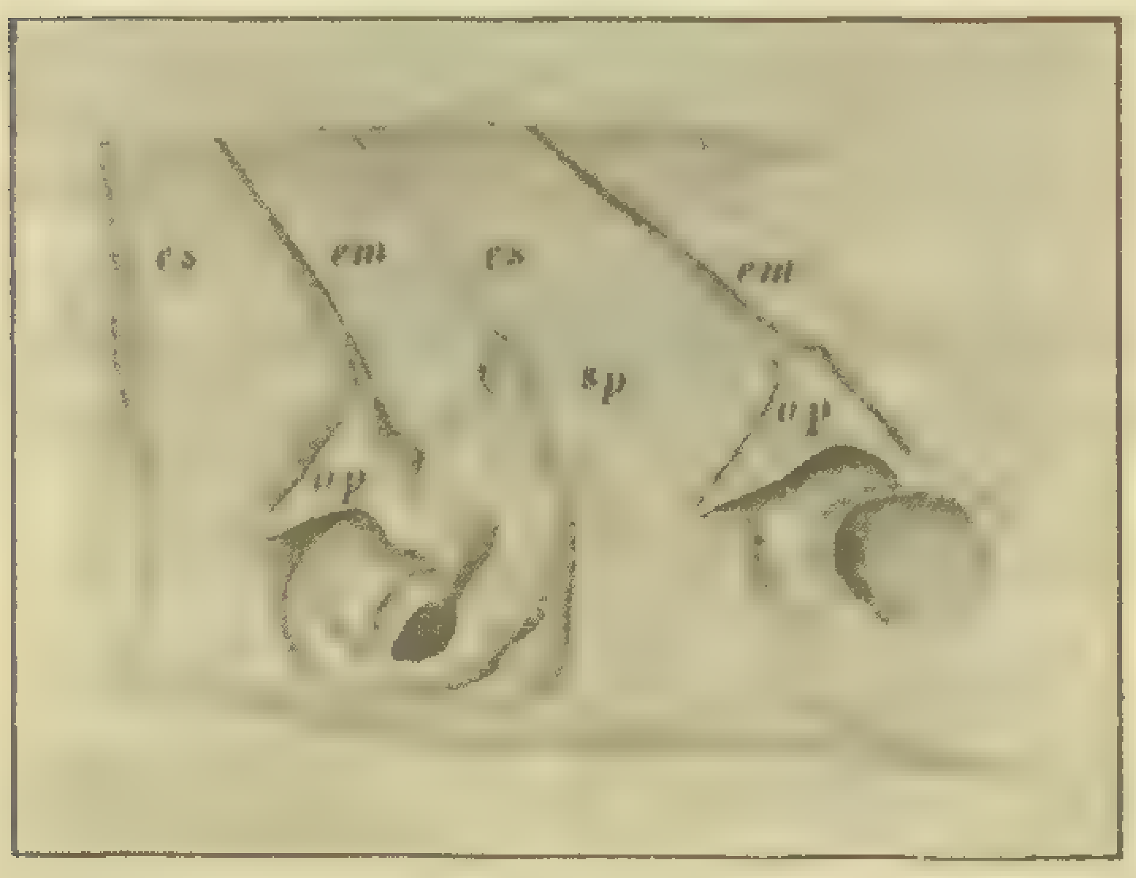

Fig. 16. — Ental surface of the pleurites of the meso- and metathorax of Melanoplus, showing the lateral apodemes.

In the same way that the position of the furca determines the line of union of the subsegments on the ventral aspect of a thoracic segment, the line of union of the subsegments on the pleural aspects is determined by the position of the lateral apodemes. Each of these is an invagination of the body-wall between the episternum and the epimeron. Fig. 16 represents the inner surface of the pleurites of the meso- and metathorax of Melanoplus and shows the form of the lateral apodemes (*ap*).

For the purposes of this paper, it is not necessary to discuss the structure of the tergal aspect of the typical segment beyond a reference to the median suture, which represents the line of the closure of the embryo. This suture has been well preserved in the head and thorax, as it is the chief line of rupture of the cuticle at the time of molting.

The relations of the appendages to a typical segment are illustrated by the accompanying figure (Fig. 17) of the base of a leg of a cockroach. Near the point marked x the coxa articulates with the ventral end of the foot of the lateral apodeme of the segment, *i.e.*, with the ventral end of the episternum and the epimeron. This may be termed *the pleural articulation*

of the coxa. In front of the coxa there is a triangular *trochantin* (*tr*), with its apex pointing towards the middle line of the body. Between the trochantin and the ventral arm of the episternum there are two sclerites, — one next the trochantin, *the antecoxal piece*; and one next the episternum, not yet named, which may be termed the *second antecoxal piece.* The antecoxal piece at its mesal extremity (*y*) articulates with the coxa. This articulation may be termed *the ventral articulation of the coxa.*

FIG. 17.— The base of a leg of a cockroach.

THE SCLERITES OF THE HEAD AND NECK.

The segments of the body of an insect do not fall into three well-marked groups, — head, thorax, and abdomen, — as commonly defined in the text-books. Between the head and the thorax there is a more or less distinct neck, which in some insects contains several sclerites. As we believe that these cervical sclerites form a part of the second maxillary or labial segment, it is necessary to include them in a discussion of the sclerites of the head. We shall return to them later.

If an embryo insect be examined after the appearance of the mouth and the appendages, the cephalic end of the body will be found to consist of a central swelling, the *procephalon* (Fig. 7, *pr*), and a large lobe on each side, the *cephalic lobes* (Fig. 7, *cl*).

The procephalon has been commonly described as the rudiment of the clypeus and the labrum. This is doubtless correct if the term *clypeus* be taken in the broader sense by which it includes the clypeus anterior and the clypeus posterior of Newport; and this is evidently the sense in which it has been used by nearly all writers on the embryology of insects. Hence, according to the nomenclature adopted in this paper, the procephalon is the rudiment of the front, clypeus, and labrum.

This conclusion makes evident the significance of the epicranial suture. The sclerites lying in front of the arms of

this inverted Y-shaped suture are those developed from the procephalon, while the stem of the Y represents the line of union of the cephalic lobes.

When we take into account the position of the mouth (see Fig. 11), it is evident that the parts developed from the procephalon pertain to the ventral aspect of the body. In the course of development there is a dorsal flexure of the cephalic region by which the preoral sterna are bent up towards the tergal aspect (Huxley, **'78**, p. 343); this has been described by several observers (see Korschelt and Heider, **'99b**, p. 302).

As a result of this dorsal flexure, the former most anterior part of the procephalon assumes a more backward position, which led to the part derived from it being termed by Newport the *clypeus posterior*. As this term is morphologically incorrect, we have adopted the name *front* for this part, and restrict the term *clypeus* to the clypeus anterior of Newport.

It seems obvious that the three sclerites derived from the procephalon, — the front, the clypeus, and the labrum, — represent the sternites of the three preoral segments.

As to the front, it bears the median ocellus, and, in the Plecoptera, the paired ocelli also; and as the ocelli are innervated by the protocerebrum, it is evident that the front is a part of the protocerebral segment.

In this connection reference should be made to a migration of the paired ocelli. The condition in the Plecoptera, where the front bears all the ocelli, is probably the most generalized; for in this order, as will be shown later, the most nearly primitive position of the antennæ is found; and, too, in this order the most generalized condition of the tracheation of the wings exists (Comstock and Needham, **'98**, p. 237). In the Orthoptera (Blattidæ and Gryllidæ) the paired ocelli are in the suture between the front and the vertex. In certain Ephemerida the paired ocelli are in this suture, while in others they have passed on into the vertex. In the more specialized orders, wherever we have been able to distinguish between the front and the vertex, we have found the paired ocelli in the vertex.

The labrum is innervated by the tritocerebrum; for this reason we regard it as the sternite of the tritocerebral segment,

or rather as a part of this sternite; for, as the invagination of the stomodæum is surrounded by the labral rudiment, the labrum represents only that part of this sternite that lies cephalad of the mouth.

The clypeus (clypeus anterior) is a sclerite between the front and the labrum; for this reason, we believe it to be the sternite of the intermediate of the three preoral segments, the deutocerebral.

We have described the sclerites derived from the procephalon as representing the sternites of the preoral segments. But strictly speaking, we believe that each represents only the median field of a sternite (Fig. 15, *mf*), and that the lateral elements of the sternites have not been separated from the pleural portions of the lateral fields of the segments; in other words, that the early embryonic divisions of the segments have been retained, and that those parts derived from the lateral fields of the segments form a single sclerite on each side of each segment.

In the ocular segment each lateral sclerite constitutes one-half of the vertex and the corresponding gena, the line of union of the lateral sclerites being the stem of the Y-shaped epicranial suture.

Each lateral sclerite of this segment bears a compound eye, except in cases where they have been lost and except in the larvæ of metabolous insects, in which the development of these organs is retarded; this is obviously a secondary condition, like the internal development of the wings in the same forms.

The position of the compound eye, in the lateral sclerite slightly removed from the middle field of the sternite (the front), is that in which one would expect to find an appendage, and it seems to us that the question whether or not the compound eyes represent the appendages of the ocular segment is still an open one.

Heretofore the chief reason for regarding the compound eyes as representatives of appendages has been the stalked condition of them in certain Crustacea; but later writers are inclined to regard the eye-stalks "as secondarily abstricted lateral portions of the head which have become independently movable" (Korschelt and Heider, '99a, p. 165).

We are inclined, however, to return to the old view; for we find that in many insects each compound eye is situated in the axis of an annular sclerite, which may be the basal segment of the ocular appendage. Certainly if the eyes were merely specialized portions of the lateral sclerites, we should not expect them to be surrounded by a ring-like suture, which in some cases is comparatively remote from the specialized portion of the body-wall that forms the eye.

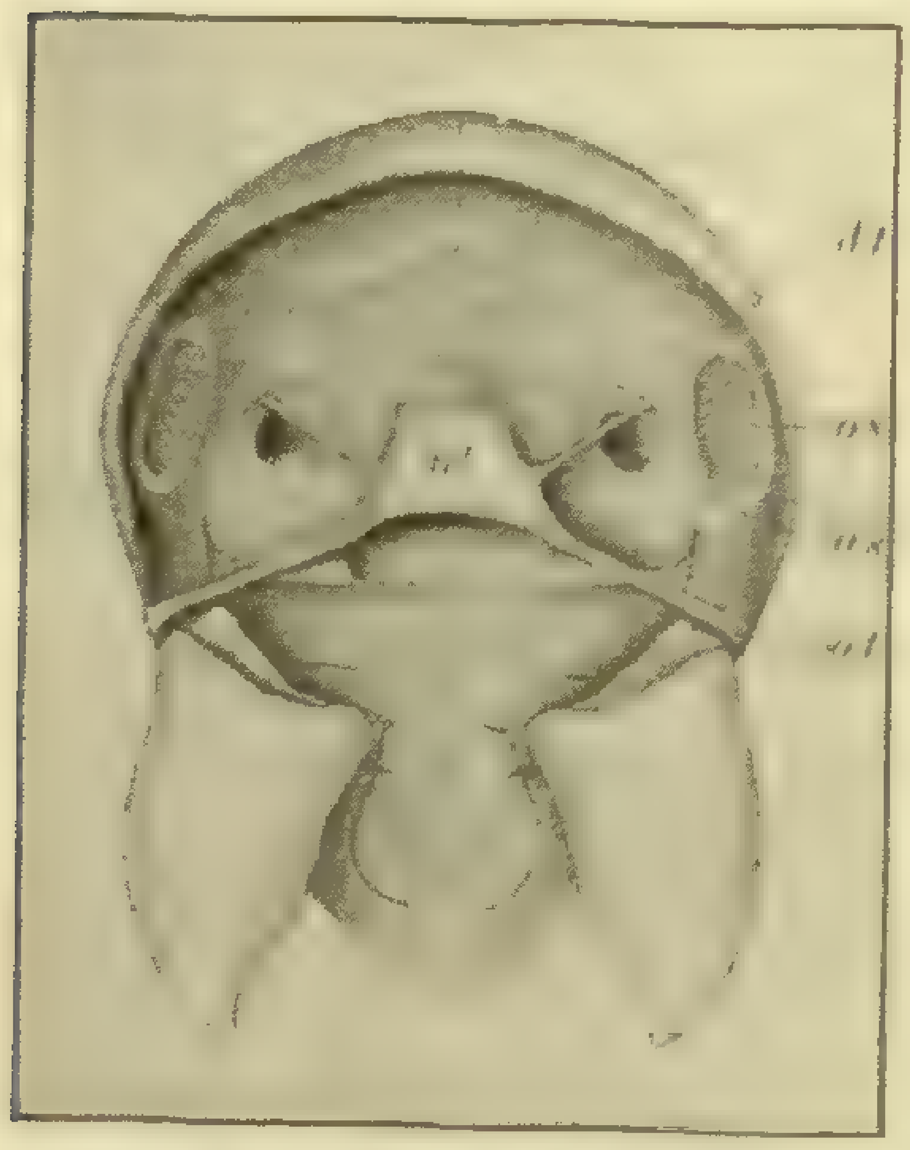

FIG. 18. - Head of a cricket, ental surface of the dorsal wall.

These sclerites bearing the compound eyes may be termed *the ocular sclerites*; they are represented in Fig. 18, *os*.

Passing to the second segment, we find at the base of each antenna an annular sclerite (Fig. 18, *as*), which is distinct in comparatively few insects and which has not been described. It is most clearly shown in the Plecoptera (Fig. 19, *as*). This we believe represents the lateral field of the antennal segment, *i.e.*, the lateral element of the sternite and what is left of the pleural element of the segment, which is greatly reduced. This sclerite may be termed *the antennal sclerite*.

The position of the antennal sclerites should be discussed. If the clypeus represents the median field of the sternite of the antennal segment, as we believe, the primitive position of the antennal sclerites was laterad of the clypeus, and we should expect to find the rudiments of them in this position, *i.e.*, laterad of the procephalon, in the early stages of the embryo. Many observers, however, have described the antennæ as arising in a postoral position; how can this be explained? A study of the figures given by these authors [1] shows that while a line connecting the two antennæ would pass in some cases behind the mouth, it is by no means so clear that the basal part of the rudiment of the antennal sclerite does not abut against the procephalon. In fact, the very figures given to

[1] Weismann, '63, Fig. 22; Graber, '88; Figs. 1 and 2; Heider, '89, Fig. 102 (Fig. 7 above); Patten, '88 (Fig. 10 above).

support the view that the antennæ are postoral in the early embryo support the opposite view.

A migration cephalad of the antennæ has been noted by many observers; and it is obvious that the position of the antennæ in adult insects is more or less remote from the primitive position.

In the Plecoptera is to be found the most generalized condition of the antennal sclerites yet observed in postembryonic stages of insects (Fig. 19); here they are distinct sclerites, and are only slightly removed from the clypeus, compared with their position in the more specialized insects. Even here, however, they are opposite the front, having been pushed out of place by a migration of the mandibles and the antecoxal pieces, to be described later.

In most insects each antenna has migrated along the suture between the front and the gena, and occupies a position on the lateral border of the front remote from the clypeus. Even in so generalized an insect as a cockroach (Fig. 2), the antenna has reached a point opposite the cephalo-lateral angle of the vertex. Here it is remote from the anterior arm of the tentorium; while in Pteronarcys it is very close to it.

In the case of the second antennal segment, the reduction has been so great that we have been able to find in the Pterygota no trace of the parts derived from the lateral fields of the segment; the labrum is the only well-marked remnant of this segment represented in the skeleton; it is possible that the lateral elements are fused with the genæ. It is probable that a study of those Apterygota in which the second antennæ are retained will reveal the presence of distinct lateral sclerites pertaining to this segment.

FIG. 19. — Head of a nymph of Pteronarcys.

In taking up the study of the postoral segments of the head, the subject can be treated most easily by beginning with the labial segment and proceeding forward to the point reached in the above discussion.

In the early embryonic stages the labial segment is obviously a body segment (Fig. 6, *2ᵈmx*); but in the course of the

development of the embryo it moves forward, and in adult insects it constitutes the dividing line between the head and the thorax, forming the neck. Its appendages, the second maxillæ or labium, however, have moved forward so that they are either loosely attached to the ventral wall of the head (Plecoptera, Orthoptera, *et al.*) or, in the more specialized orders, they contribute to the formation of the fixed parts of the head.

While the appendages of this segment have been retained and play an important rôle as a part of the mouth organs, the segment itself is greatly reduced, being represented by small and more or less detached sclerites, the cervical sclerites.

Straus-Durckheim ('28) suggested that the cervical sclerites represent the remains of two segments situated originally between the head and prothorax. Newport ('39) regarded them as detached portions of the prothorax; and Huxley ('78) wrote: "I think it probable that these cervical sclerites represent the hindmost of the cephalic somites." But we find no account of these sclerites that contains more than a suggestion regarding their homologies. No evidence has been brought forward to support any of the conclusions, beyond the position between the head and thorax occupied by these sclerites. We have been led to adopt the view put forth by Huxley for reasons that seem to us conclusive, and which we will now state.

FIG. 20. — Lateral cervical sclerites of Melanoplus.

The cervical sclerites are best preserved in the Orthoptera. In this order a variable number occur in the ventral wall of the neck; two in each lateral wall; and in some forms, two in the dorsal wall.

Between the two lateral cervical sclerites there is in certain forms, as Melanoplus and Stenopelmatus, a prominent apodeme (Fig. 20, *ap*). This apodeme we regard as homodynamous with the lateral apodemes of the thoracic segments. Each of these apodemes is an invagination between an episternum and an epimeron; we, therefore, conclude that the anterior lateral

cervical sclerite is the episternum of the labial segment, and the posterior one the epimeron. This conclusion is confirmed by the fact that the posterior of the two lateral cervical sclerites articulates with the episternum of the prothorax, and the anterior one with what we believe to be the epimeron of the maxillary segment.

Fig. 21. — Ventral and lateral cervical sclerites of Periplaneta.

The ventral cervical sclerites in this order are either two in number, Periplaneta (Fig. 21), or constitute two transverse series, Stenopelmatus (Fig. 22), Gryllus (Fig. 23). We regard these as constituting the sternites of the two subsegments of the labial segment. If this view be correct, the anterior sclerite or series of sclerites represents the sternum of the labial segment, and the posterior the sternellum. The division of a sternite into a transverse series of either two or three sclerites is comparable with what frequently takes place in the sternites of the thorax and of the abdomen, already discussed on an earlier page.

Fig. 22. — Head of Stenopelmatus, ventral aspect.

The appendages of this segment, the second maxillæ, project forwards from the front margin of the segment as a single organ, the labium. This anomalous condition is the result of a migration of the appendages forwards and towards each other and of a coalescence, which has been figured by many writers and often described, lately in detail by Deegener ('00). As a result of this coalescence the united cardines become the submentum, and the stipites the mentum.

Fig. 23. — Ventral cervical sclerites of Gryllus.

In the more generalized insects a gula is not developed as such. We have devoted much study to the question of the homology of the gula and conclude that

it is the sternum of the cervical segment which has migrated cephalad and become a part of the skull. In Corydalis the sternellum of the cervical segment is retained back of the gula (Fig. 5, S_2).

Although the maxillæ are well-developed organs, the maxillary segment itself is greatly reduced. The most conspicuous element of it is the lingua, the unpaired portion of the hypopharynx. This, as has been shown (Fig. 8, *l*), arises between the rudiments of the maxillæ and evidently pertains to the sternite of this segment.

The opening of the salivary glands is in the lingua. Carrière has shown that these glands arise as the spiracular invaginations of the prothorax, and that their openings migrate cephalad, and towards each other, finally forming a single opening in the lingua (Carrière and Bürger, **'97**). This explains the absence of spiracles in the prothorax, and is one of the most remarkable instances of the migration of organs and change in function yet described.

Regarding the maxillary pleurites of the completed head, almost nothing has been published. Huxley, in his description of the structure of the cockroach (**'78**), stated that the cardo of the maxilla is articulated "with a thin skeletal band which runs round the posterior margin of the epicranium." He made no suggestion regarding the homology of this sclerite; and subsequent writers do not appear to have done so.

This lateral band (Fig. 4, *m.em.*) is one of two sclerites, between which is the invagination which forms the posterior arm of the tentorium ; the other of these two sclerites, the anterior one, is much more reduced than this one, still it can be seen in Periplaneta and in Gryllus. The articulation of the maxilla is at the ventral end of these sclerites just ventrad of the invagination between them, the open mouth of which is very conspicuous in the more generalized insects.

The relation of these parts corresponds exactly with what exists in a thoracic segment, where each leg is articulated just ventrad of the lateral apodeme, which is an invagination between the episternum and the epimeron. Evidently the band described by Huxley is the epimeron of the maxillary segment,

the thinner band in front of the invagination is the episternum, and the invagination itself is the lateral apodeme of this segment.

From this it will be seen that the posterior arms of the tentorium are to be homologized with lateral apodemes instead of with spiracles, as is often done. It should be borne in mind, however, that the spiracles are lateral invaginations between segments, and that the lateral apodemes are invaginations in a similar position between subsegments (Fig. 16). If each segment consists of two consolidated metameres, the lateral apodemes and spiracles are homodynamous structures. The solution of this question must wait, however, the solution of the larger question, the structure of the segment in air-breathing arthropods; we need not dwell upon it here.

The superlingual segment is so greatly reduced that we are able to find no trace of the lateral elements of it in the skeleton; if they exist, they are inseparably united with the mandibular pleurites. The sternal elements are represented by that part of the floor of the mouth cavity that bears the superlinguæ; and the appendages of the segment, by the superlinguæ themselves. In the Pterygota these parts are greatly reduced and have received but little attention. Fig. 24 represents the hypopharynx of Melanoplus, in which the lingua is very prominent, and what we regard as the superlinguæ are reduced to a pair of small sclerites. As the superlinguæ have been carried into the mouth cavity by its invagination, they lie behind the lingua, although they originated in front of it. The superlinguæ are connected with the skull by a membranous portion of the body-wall, which, on each side, extends between the attachments of the maxilla and of the mandible.

Fig. 24. — Hypopharynx of Melanoplus.

In the mandibular segment the pleurites are represented by the postgenæ, which, excepting the vertex and genæ, are the most prominent sclerites of the head in many Orthoptera.

The suture separating the postgenæ from the genæ is well-marked on the lateral aspect of the head in the Orthoptera. In most forms it is obsolete on the dorsal aspect but in a large South American cockroach that we have studied the postgenæ are separated from the genæ and vertex throughout their entire extent. Upon the presence or absence of this suture on the dorsal wall of the head depends the presence or absence of the so-called occiput; the occiput being the tergal portions of the postgenæ (Fig. 3, *O*, *O*).

In the ventral end of each postgena there is an acetabulum into which a condyle of the mandible fits (Fig. 25). Beginning in this acetabulum and extending dorsad there is a suture which divides the postgena into two parts; this suture is the more or less open mouth of an apodeme which extends into the cavity of the head.

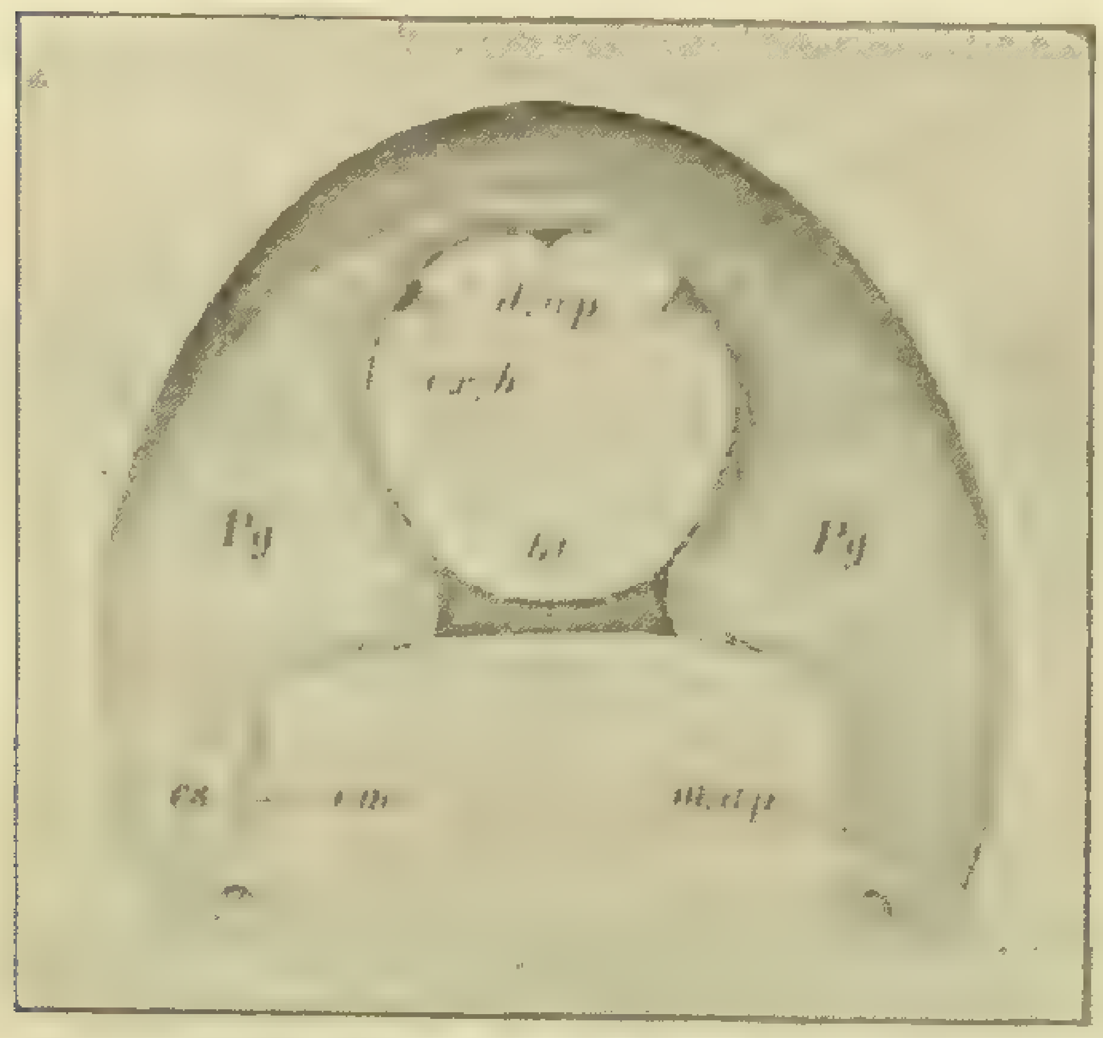

FIG. 25.— Head of a cricket, caudal aspect.

Here again the same relation of parts exists that is found in a thoracic segment. The mandible is the basal segment (coxa) of an appendage, which articulates with the ventral ends of two sclerites (episternum and epimeron), between which there is a lateral apodeme.

Thus we see that three of the head segments — the labial, the maxillary, and the mandibular — closely resemble a thoracic segment, in having on each side two sclerites, with an apodeme between, and an appendage below except in the case of the labial segment, where there has been a cephalization of the appendages.

In the floor of the mouth cavity of Melanoplus there is on each side just behind the superlinguæ a sclerite (Fig. 24, *ps*) which may represent a sternal element of the mandibular segment. The position of this sclerite farther in the mouth cavity than the superlinguæ is that which would be occupied by a mandibular sternite, as such a sternite must precede the superlinguæ in the course of the invagination of the mouth; equally suggestive is the fact that this sclerite is closely connected

with the mandible, joining it near the insertion of the flexor muscle. But in the present state of our knowledge little stress can be laid on supposed homologies of the parts of the pharyngeal skeleton; for it is evident that in this region sclerites are frequently developed secondarily.

The articulation of the mandible with the postgenæ is its pleural articulation; the ventral articulation appears to be with the clypeus in Periplaneta (Fig. 2), *i.e.*, with the sternite of the second segment in front of the mandibular segment. It is difficult to imagine the steps by which, in the course of the phylogenetic development of cockroaches, this condyle of the mandible could pass from one segment to another without interfering with the usefulness of the mandible during the transition period. This was for us a perplexing problem for a long time.

Later it was found that in Gryllus (Fig. 1) the mandible articulates with a small sclerite which is sometimes distinct from the clypeus. The same thing was found in the larva of Corydalis, except that here (Fig. 3, *ac*) the sclerite is large and clearly distinct.

As the ventral articulation of a coxa is with an antecoxal piece (see page 27), we regard this sclerite as the antecoxal piece of the mandible. In the course of the consolidation of the segments of the head and of the dorsal flexure of the sternites of the first three segments (the procephalon), the antecoxal piece of the mandible has been pushed out of its own segment past the labrum (the sternite of the second antennal segment) and, in Gryllus, nearly past the clypeus. Such a migration of the antecoxal piece could take place without interfering with the action of the mandible.

Doubtless a factor in bringing about these changes is the fact that while there has been a marked reduction in the length of the head segments (the entire head composed of seven segments being approximately of the same length as a single segment elsewhere), there has been no reduction in the width of the base of the mandible in biting insects. It is not strange, therefore, that the least firmly fixed point of articulation, the antecoxal piece, should be pushed out of its primitive position.

In most insects the antecoxal piece of the mandible coalesces with the clypeus, so that the mandible appears to articulate with this sclerite.

In some insects, as Orthoptera, there is a distinct sclerite between the mandible and the gena (Fig. 1, *tr*). This from its position on the cephalic side of the base of the mandible between the pleural and ventral articulations must be regarded as the *trochantin* of the mandible.

This completes our account of the sclerites found in the external skeleton of the head of the more generalized insects. A *résumé* of the conclusions reached is indicated by the following table.

SEGMENTS, SCLERITES, AND APPENDAGES OF THE HEAD.[1]

SEGMENTS.	SCLERITES.	APPENDAGES.
I. Ocular (Protocerebral).	Vertex and genæ. . . . . Front.	Ocular sclerites.
II. Antennal (Deutocerebral).	Antennal sclerites. . . . . Clypeus proper.	Antennæ.
III. 2d Antennal (Tritocerebral).	. . . . Labrum (Mouth).	2d Antennæ of Campodea *et al.*
IV. Mandibular.	Postgenæ. . . . . : Antecoxal pieces. Pharyngeal sclerites.	Mandibles. Trochantin.
V. Superlingual.	. . . .	Superlinguæ.
VI. Maxillary.	Maxillary pleurites. . . . . Lingua.	Maxillæ.
VII. Labial.	Dorsal cervical sclerites. Lateral cervical sclerites. . . . . Ventral cervical scl. (Gula).	Labium.

[1] In each section of the middle column the dotted line indicates the division between the sternal and the lateral elements of the segment.

The Endoskeleton of the Head.

The endoskeleton of the head, like that of the thorax, consists of invaginations of the body-wall and of chitinized tendons. Some of these invaginations may be homodynamous with thoracic tracheæ, but others are obviously apodemes.

In many insects the mouths of some of the invaginations of the wall of the head remain open in the adult; in Corydalis, for example, they are very conspicuous.

Some of the apodemes remain separate, and are comparatively simple; but in the case of two or three pairs of invaginations, they meet and coalesce. In this way there is formed in the interior of the head a complicated structure which is known as the *tentorium* (Burmeister, '32, Vol. I, p. 25).

The three pairs of invaginations which may enter into the formation of the tentorium are known as the *anterior*, the *posterior*, and the *dorsal arms of the tentorium* respectively. The coalesced and more or less expanded tips of these invaginations constitute the central portion of the tentorium, and may be designated as the *body of the tentorium*. From the body of the tentorium there extends a variable number of processes or chitinized tendons.

The Posterior Arms. — The posterior arms of the tentorium (Figs. 26, 28, 29, *pt*) are the lateral apodemes of the maxillary segment. In many Orthoptera the open mouth of the apodeme can be seen on the lateral aspect of the head, just above the articulation of the maxilla (Fig. 4). In the Acrididæ (Fig. 28) these apodemes bear a striking resemblance to the lateral apodemes of the thorax (Fig. 16), except that the ventral process of the maxillary apodeme is much more prominent, and the two from the opposite sides of the head meet and coalesce, thus forming the caudal part of the body of the tentorium.

The Anterior Arms. — Each anterior arm of the tentorium (Figs. 26, 27, 29, *at*) is an invagination of the body-wall which opens on the cephalic margin of the antecoxal piece of the mandible (Fig. 2, *at*),[1] or, when the antecoxal piece is not distinct,

[1] Note that owing to the flexure of the head in those insects, like Corydalis, in which the mouth is at the anterior end of the body, the opening of the anterior arm appears to be on the caudal side of the antecoxal piece.

usually on the cephalic side of the cephalo-lateral angle of the clypeus (Fig. 2, *at*). (It should be borne in mind that the cephalic margin of the clypeus is that margin which joins the front; that morphologically the labrum is caudad of the clypeus.)

It has been shown by Carrière and Bürger ('97) that the position of this invagination in the young embryo indicates that it is the spiracle of the mandibular segment. It is easy to see that the migration cephalad of the antecoxal piece of the mandible, already described, would push this invagination into the position which it occupies in the adult insect.

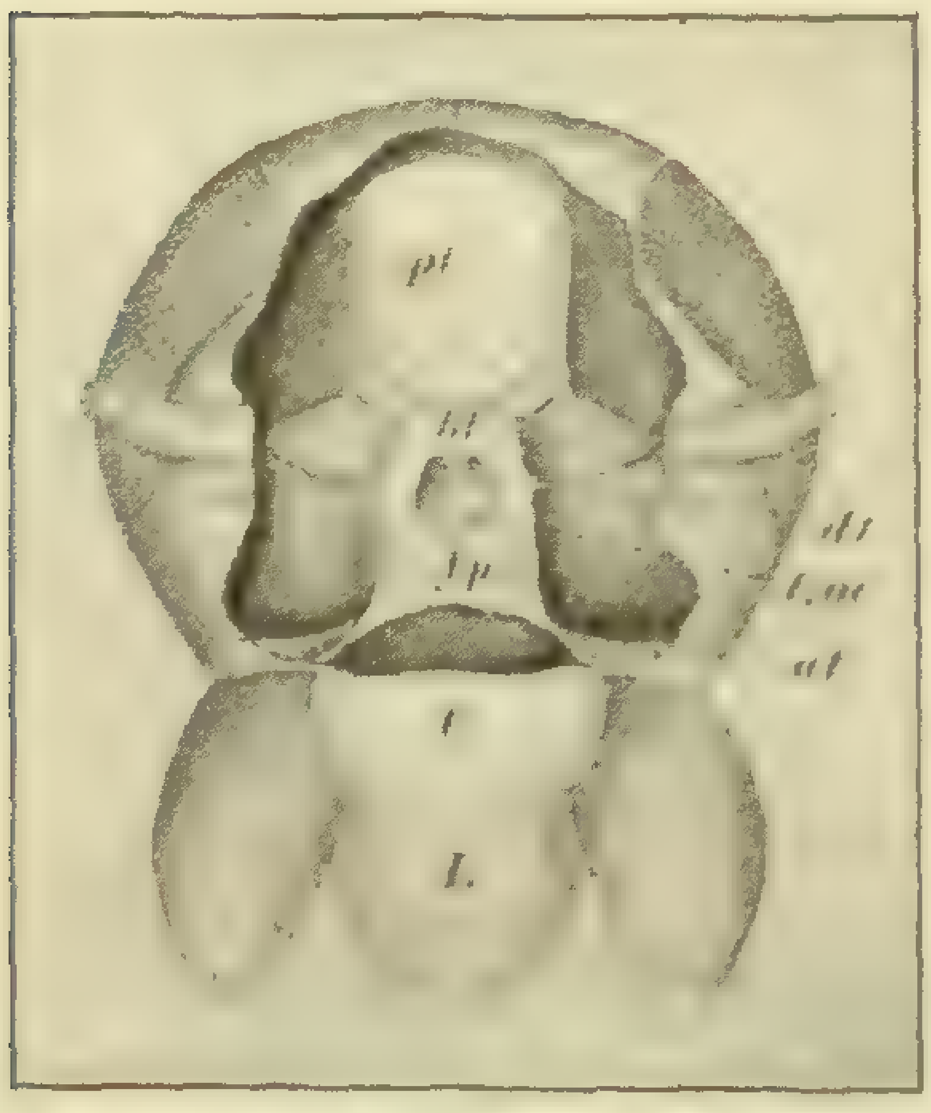
FIG. 26. — Tentorium of a cockroach, dorsal aspect.

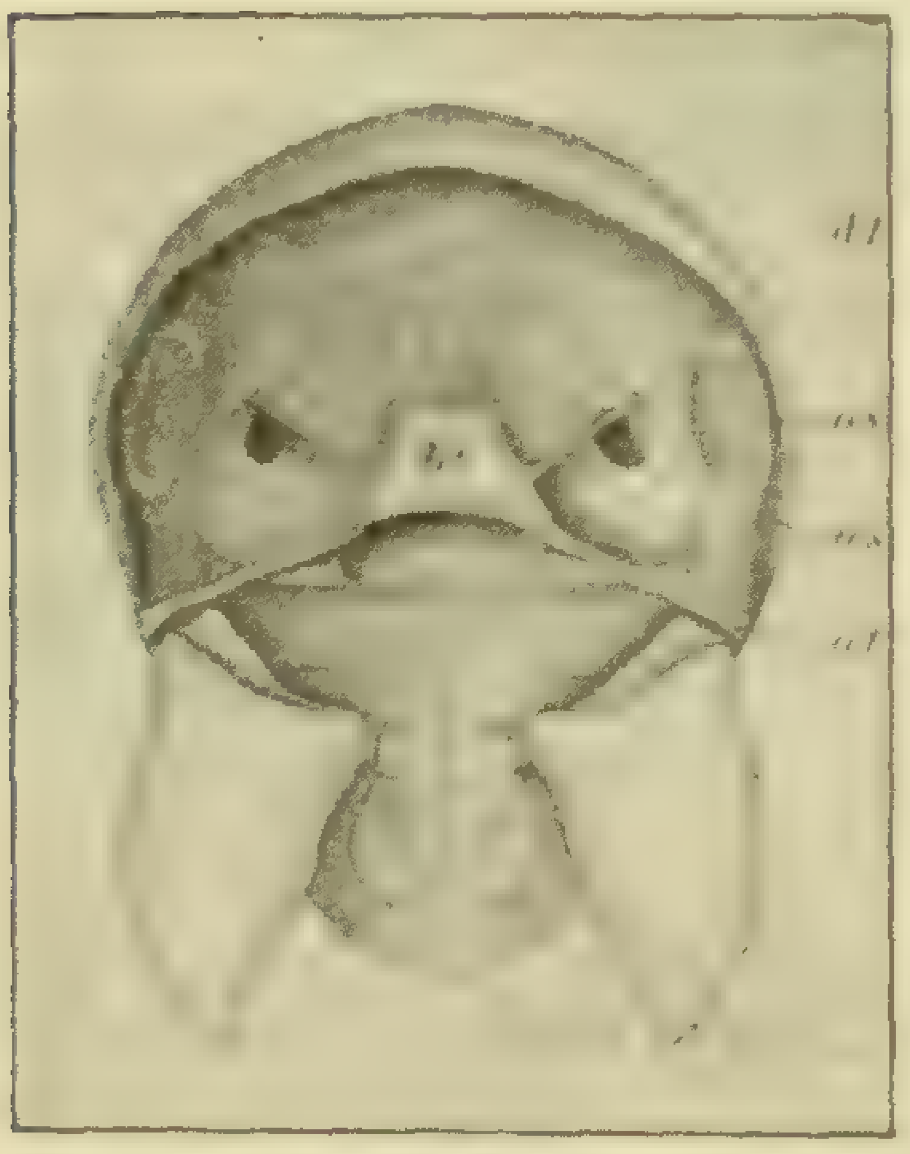
FIG. 27. — Part of the tentorium of a cricket, ventral aspect.

Bearing on this point is the fact that in Smynthurus, according to Lubbock ('73), the spiracles "open on the inner side of the bases of the mandibles." It remains to be determined whether in this case the anterior arms of the tentorium are wanting or not. Folsom ('00) found that, although the three pairs of arms are present in the collembolan Orchesella, the anterior arms are wanting in Anurida. In Orchesella where the anterior arms are present they are described by Folsom ('99a) as being joined to the paraglossæ (superlinguæ). But as the invaginations forming the anterior arms arise cephalad of the mandibles (Carrière and Bürger, '97), they cannot pertain to the superlingual segment.

Usually the invagination forming the anterior arms is extended to a greater or less degree along the sutures that converge upon it. This is well shown in Gryllus, where it is furnished with three buttress-like extensions: one along the suture between the front and the clypeus; another between the front and the gena; and a third between the gena and the trochantin of the mandible.

In the cockroach (Fig. 26) the buttress of the anterior arm that extends along the suture between the front and the gena is twisted in a way that suggests that it has been pulled out of place by the migration of the antenna. If we imagine the antennal sclerite pushed into a position which would untwist this buttress, it would bring this sclerite opposite the clypeus, that is, in its assumed primitive position.

Fig. 28. — Head of Melanoplus, caudal aspect.

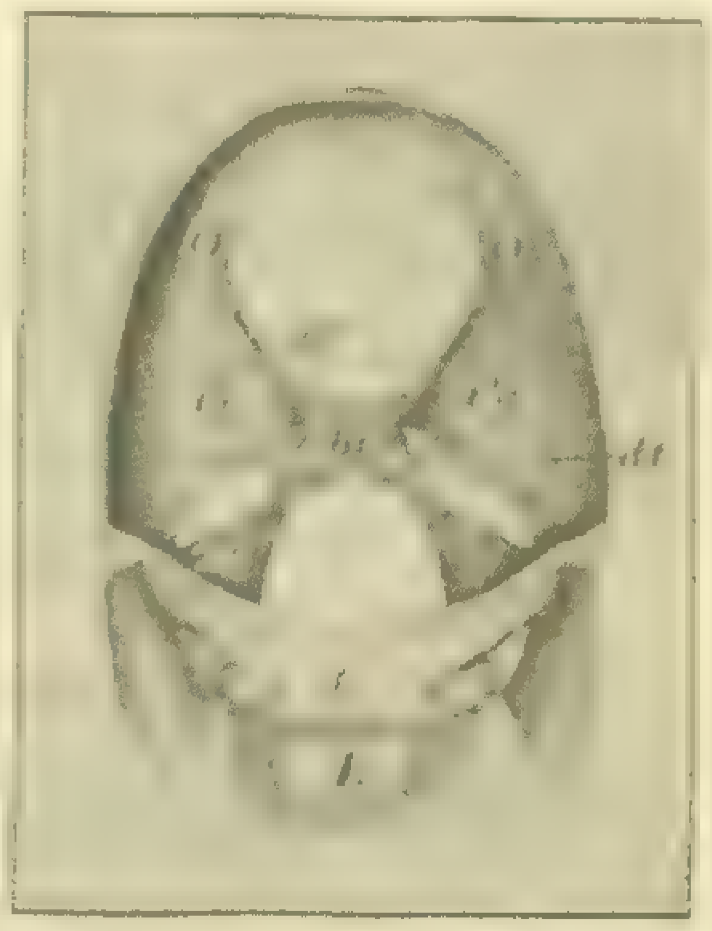

Fig. 29. — Tentorium of Melanoplus, cephalic aspect. The distal end of the dorsal arms detached.

In the forms upon which the study is chiefly based, — the Plecoptera, the Orthoptera, and the Neuroptera (Sialidæ), — the antecoxal piece of the mandible is joined to the clypeus near its cephalo-lateral angle as described above. But in the Hymenoptera that we have studied it is joined to the caudo-lateral angle of the clypeus very near the labrum. A result of this in some forms is that the point of invagination of the anterior arm is remote from the front, as in the ants, although even here the buttress-like extension follows the margin of the clypeus and extends along the suture between the clypeus and the front. In other Hymenoptera the opening of the invagination has migrated to the cephalo-lateral angle of the clypeus and is thus remote from the articulation of the mandible ; this is the case in Bombus.

The Dorsal Arms. — Each dorsal arm of the tentorium arises from the side of the body of the tentorium between the anterior and posterior arms and extends either to the front or to the margin of the antennal sclerite (Figs. 26, 27, 29, *dt*).

In the Plecoptera it appears to be merely a chitinized tendon, the peripheral end of which is less chitinized than the base and is only loosely attached to the skull. Here the point of attachment is on the front, some distance from the antennal sclerite, beneath a spot in the cuticle, which is marked by numerous polygonal areas. This spot is very distinct and bears some

resemblance to an ocellus (Fig. 19, *dt*). In the Orthoptera the peripheral end is more strongly chitinized than in the Plecoptera and firmly attached to the skull between the front and the antennal sclerite. It is small in the cockroaches, but is larger and easily seen in Gryllus (Fig. 27). In this case it bears some resemblance to an apodeme.

The resemblance to an apodeme is much more marked in some other insects. Thus in the Hymenoptera each dorsal arm is firmly attached to the skull near the antennal sclerite, and, in Cimbex for example, it is hollow and has an open mouth, appearing exactly like an apodeme.

It remains to be determined whether or not the dorsal arms in the Plecoptera are homologous with the apodeme-like dorsal arms in other insects, and, if so, which type is the more generalized.

The Body of the Tentorium. — This is the part to which the name *tentorium* was originally applied. It is the prominent bridge which divides the occipital foramen into two parts. The alimentary canal in entering the head passes above it, and the nervous system below it. It is formed of the coalesced and expanded tips of the arms of the tentorium (Fig. 28, *bt*).

The Frontal Plate of the Tentorium. — In the cockroaches the anterior arms of the tentorium meet and fuse, forming a broad plate situated between the crura cerebri and the mouth; this plate may be termed the *frontal plate of the tentorium* (Fig. 26, *fp*). On each side, an extension of this plate connects it with the body of the tentorium; these enclose a circular opening through which pass the crura cerebri.

The Tendons of the Œsophageal Muscles. — Muscles extend from the body of the tentorium to the œsophagus, passing between the crura cerebri. The tendons connecting these muscles with the body of the tentorium are frequently chitinized. In Pteronarcys there is a single chitinized tendon; in Periplaneta there are two (Fig. 26, *t.oe*).

The Tendons of the Flexors of the Head. — These arise from the lower surface of the body of the tentorium and extend caudad. Sometimes, as in Stenopelmatus, they are large and strongly chitinized.

The Tendons of the Extensors of the Head. — These are strongly developed in Gryllus; they project into the occipital foramen (Fig. 25, *ex.h.*).

The Dorsal Apodeme of the Head. — This is also well developed in Gryllus (Fig. 25, *d.ap.*).

The Lateral Cervical Apodemes. — These have been described above (see Fig. 20, *ap*).

The Mandibular Apodemes. — These also have been described above (see Fig. 25, *m.ap*).

In this study of the skeleton of the head our attention has been confined almost entirely to representatives of the more generalized orders of insects. We have felt that to do so was the surest way to gain an idea of the fundamental plan of structure. The working out of the ways in which this plan has been modified in the more specialized groups of insects must be left for the future and perhaps for other workers.

LIST OF ABBREVIATIONS.

ac.	Antecoxal piece.
ant.	Antenna.
ap.	Apodeme.
as.	Antennal sclerite.
at.	Anterior arm of the tentorium.
bt.	Body of the tentorium.
C.	Clypeus.
C_1.	First clypeus.
C_2.	Second clypeus.
cl.	Cephalic lobes.
d. ap.	Dorsal apodeme.
dt.	Dorsal arm of the tentorium.
em.	Epimeron.
es.	Episternum.
e. su.	Epicranial suture.
ex. h.	Extensors of the head.
F.	Front.
fp.	Frontal plate of the tentorium.
G.	Gena.
Gu.	Gula.
L.	Labrum.
l.	Lingua.
lf.	Lateral field.
lg.	Leg.
md.	Mandible.
m. em.	Maxillary epimeron.
mf.	Middle field.
mx.	Maxilla.
O.	Occiput.
os.	Occular sclerite.
Pg.	Postgena.
pl.	Pleurite.
pr.	Procephalon.
prs.	Præsternum.
ps.	Pharyngeal sclerites.
pt.	Posterior arm of the tentorium.
S.	Sternum.
S_2.	Sternellum.
sl.	Superlingua.
sp.	Spiracle.
t. oe.	Tendons of the œsophageal muscles.
tr.	Trochantin.
V.	Vertex.
2d mx.	Second maxillæ or labium.

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ON THE HABITS OF THE KANGAROO RATS IN CAPTIVITY.

DR. R. W. SHUFELDT.

SOME time during the early part of the month of June or the latter part of May, 1901, Mr. Edward S. Schmid, a dealer in pets and animals, with an establishment at 712 Twelfth Street, Washington, D.C., received from one of his collectors in Kansas some two dozen specimens of "kangaroo rats." At first glance I did not recognize the species; but Mr. Schmid, with his usual generosity, presented me with three of the finest specimens in the lot, — two males and a female.

Upon taking these to my study I consigned them to a roomy cage with an inch or more of soil on the bottom of it, and I soon found that these very interesting little mammals fed with great avidity upon hemp and canary seed mixed up with a supply of wheat grains. They also drank freely of water placed for them in little china vessels.

After they had been in my possession a day or two, I found they had become sufficiently accustomed to my presence and handling to allow me to make the attempt to obtain photographs of them. This I undertook on two separate occasions, selecting for the purpose the darker and better marked male animal of the trio. Both times I succeeded in obtaining life-size pictures, and the reproductions of my results, reduced rather more than one-half, illustrate the present article. Fig. 1 represents the animal as he appears when asleep during the daytime, and Fig. 2 shows him when wide awake and engaged in busily nibbling upon a piece of root at the entrance of a shallow burrow he had dug for himself. As my methods of obtaining such photographs as these have been fully set forth by me during the past year or two in the technical journals devoted to scientific photography in this country and abroad, it will not be necessary to touch upon that question here.

Upon exhibiting my photographs to Mr. Gerret S. Miller, Jr., of the Mammal Department of the United States National Museum at Washington, D.C., he at once pronounced them to be specimens of the kangaroo rat described by Dr. J. A. Allen as *Perodipus richardsoni*, a species, so far as at present known, confined to Indian Territory, Kansas, and Oklahoma.

During the last sixteen or seventeen years the number of new North American species of jumping mice and kangaroo rats described by our mammalogists has been something phenomenal.

FIG. 1.—*Perodipus richardsoni* (Allen). ♂ (asleep). Less than ½ nat. size. Photographed from life by the author.

Other genera have been similarly increased. When the United States National Museum published its provisional list of mammals of North America in 1884 (*Proc. U. S. Nat. Mus.*, Vol. VII, Appendix, p. 585), there were but two subspecies of Dipodomys recorded, and but one species of Zapus. If we turn now to the excellent volume published by Mr. D. G. Elliot, curator of the Department of Mammals of the Field Columbian Museum of Chicago (Zoöl. Ser., Vol. II, Chicago, 1901), entitled *A Synopsis of the Mammals of North America and the Adjacent Seas*, we find that there was recorded at the time of the issuance of that book no less than 23 kangaroo rats and 20

jumping mice (Zapus); 13 of the former are of the genus Dipodomys and 10 of Perodipus, the genus to which our present subject belongs. (See pp. 236, 237; Family (VI) Heteromyidæ; and for three views of the skull of *Perodipus agilis*, p. 237.) Other genera of this extensive group of our smaller rodents have likewise been largely added to, and a great many new species described of recent years. Mr. Elliot has since published a supplement to the volume here referred to, and this contains the descriptions of still other species.

I found my specimens of *P. richardsoni* extremely gentle in disposition, and any one of them would allow me to catch hold of it with my hand, and no amount of handling or even gentle squeezing could induce the little animal to bite or scratch. On one occasion I let them all out in my study, when it was very amusing to see their various antics and capers. They were as full of fun and play as could be, and soon seemed to take a genuine delight in my attempts to recapture them. They hopped about with great agility on their hind pair of kangaroo-like legs, while the little short pair of anterior limbs were curled inwards on the chest. At these times the animal's tail is simply dragged behind it, being in contact with the ground for its entire length. Its body is held obliquely, its axis making rather a small angle with the surface over which it is passing, but if occasion occurs for it to use its fore legs, they are brought into play at once, either for feeding, climbing, or burrowing. They are able climbers, and the rapidity with which they can dig a burrow in ordinary ground is astonishing. They use the fore feet to perform the digging part and the long and strong hind legs to kick the loosened soil out of their way behind, as it accumulates every moment or so. In soft soil one of these little mammals can put itself out of sight in less than a minute by digging, and it really seems to enjoy the operation. Among themselves they are somewhat inclined to be quarrelsome, biting and scratching one another sometimes without any apparent cause, while at other times they huddle together in a corner and sleep as peacefully as so many snails. The borders of the ears of one of these males, however, exhibit a few small healed-up nicks and notches that have very much

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the appearance of having been acquired during combats with its fellows. During most of the day they pass the time in sleep, but they become very active towards dusk and probably are active all night. So it is that they rarely feed during the daytime, while after dark they are hearty consumers of anything that takes their fancy, especially of such grain and seeds as I have mentioned above. When sleeping they sometimes curl their long tails about them in a circle on the ground, while the nose and face is poked well down in between the fore legs, the body thus looking like a round puffball of hair surrounded

FIG. 2.—*P. richardsoni.* Same specimen as shown in Fig. 1. Feeding. Less than ½ nat. size. Photographed from life by the author.

by a single coil of the bicolored and longitudinally striped tail, the latter terminating in a brush at its end. Again they may sleep in the attitude shown in Fig. 1, where the animal had mounted a little log for the purpose and had been in sound repose for fully ten minutes, without moving, before I exposed my plate upon him. At other times they sleep upon their backs or sides, stretched out like little kittens or other small animals that assume such attitudes when enjoying a blissful doze in the warm sunshine.

This kangaroo rat is a very neat and cleanly little creature, frequently dressing its soft fur much after the fashion of the

common house mouse. Sitting up like a kangaroo, it will vigorously, and with both fore paws, dust its nose and face for a few seconds, when, with equal alacrity, it will pass to a general scratch of its sides and back, terminating the operation by starting at the root of its long and stout tail and rapidly passing the entire appendage through its fore paws to the very tip, while it is, as it were, at the same time briskly titillated with the lips and teeth at the front of the mouth. It is very amusing to observe the evident satisfaction it has in performing this act.

In addition to preening thus the face, body, and tail, it will, to dress the hair of the belly and back, push itself along in the dust or earth by means of its hind legs, and afterwards vigorously brush out the fur with its fore paws.

Another peculiar habit I observed in Perodipus was the way it had of using its fore paws for quickly pulling out the cheek pouches. By this means the pouches were completely turned inside out; they were then stretched, scratched, and dusted for a second or two, after which the animal tucked them back into position with equal rapidity.

As in the case with the majority of the Muridæ, when startled by sharp and sudden noises these nervous little animals will involuntarily spring from the ground for a centimeter or more; when coming down again they will stand and gently grit their teeth together, while their eyes appear as though they were about to pop out of their orbits. At other times, particularly when feeding, the eyes are often kept not more than two-thirds open, and the animal then has an especially gentle look (Fig. 2).

Perodipus occasionally, at long intervals, gives vent to a peculiar note not altogether unlike the low sound of a cat when calling her kittens together, though not nearly so loud or distinct.

If kept in a roomy cage with five or six inches of soil on the bottom, where it is perfectly quiet and sunny, I see no reason why this species would not breed in captivity, and in any event they make very interesting and gentle little pets in confinement, quite equaling any of the squirrels, or even the famous dormouse of Europe, in this regard.

A CONTRIBUTION TO MUSEUM TECHNIQUE.

S. E. MEEK.

To exhibit fishes properly in a museum has been no easy task. Many methods have been devised, but none have as yet given universal satisfaction. Land animals, such as mammals, birds, reptiles, etc., are mounted and arranged in cases according to their natural order, to show relationship, or they are mounted in groups illustrating some of their habits and natural surroundings. These methods have received universal approval. With fishes the case is quite different. To mount them is difficult, and in most cases unsatisfactory, while many of the smaller soft-rayed fishes cannot be mounted. Painted plaster casts, or casts made of other material and painted, are used in some museums. In case nothing better can be had, these serve a good purpose and are especially desirable when a collection is to be exhibited at different times in various places. They are simply representations, and do not meet the desire of the visitor as do the real fishes themselves. A mounted fish is "a fish out of water," a fish robbed of his natural surroundings.

Three years ago we began some experiments in this museum to devise a metal case or vessel with a plate-glass front in which we could exhibit fishes in alcohol in a horizontal or natural position. A joint between the metal vessel and the plate glass, which would hold alcohol, and which would compensate at any temperature for the unequal expansion of the plate glass and metal, was devised by Mr. Wines, our building superintendent. Under his direction a vessel was made in December, 1898, with a plate-glass front of 18 by 36 inches. Nine species of sunfishes were placed in this vessel, and it was filled with 70 per cent alcohol, and put on the wall of one of our exhibition rooms. A few weeks later another case of 14 by 32 inches was made, and in it was placed a large blue-black trout from Lake Crescent,

Washington. These two cases have so far held satisfactorily, having been subjected to temperatures from 20° F. to 90° F. Two smaller cases put up at the same time have also proved very satisfactory.

In 1899 Dr. A. B. Meyer, director of the Natural History Museum of Dresden, made a tour of this country to study our museums and scientific institutions. It was my pleasure to escort him through the department of zoölogy in this museum. I called his attention to one of these cases and he remarked, "Very

good, but I like our method better." He kindly called my attention to an article, "Ein Beitrag zur Museumtechnik," by Dr. Max v. Brün, published in the *Abhandlungen aus dem Gebiete der Naturwissenschaften* (Bd. XIII), herausgegeben vom Naturwissenschaftlichen Verein in Hamburg, 1895. As this article is not easily accessible to all who are interested in the exhibition of fishes, I give here an abridged translation of it.[1]

The zoölogical museums are constantly progressing in their efforts to acquaint the public with the animal world by means of life-like representations. Those animals which are robbed of their natural appearance, in a greater or less degree, by insufficient

[1] Published with the permission of Dr. Brün.

methods of preservation and preparation, are gradually being replaced by properly prepared material, so that museums are constantly asking less of the fancy or imagination.

The problem of preserving natural colors in alcoholic specimens is still unsolved, and yet the impressions which animal forms make on the eye, and through it on the understanding, depend much on color. It is not so much the task of our museums to preserve the natural color of an animal as to give it a lifelike appearance after the color has faded or has been lost. If for exhibition purposes we do this properly, our methods need not be questioned. To represent absolutely true to nature an individual specimen, is in most cases as impossible as it is unnecessary; for even in nature the individuals of any species are not all made according to the same mould, but they differ from each other within certain limits, not less in color than in other characteristics. The problem of preserving natural colors is reserved for preserving liquids, as Wiese-liquid, which by means of its chemical action seems well adapted for this purpose.

Preceding the opening of the Natural History Museum of Hamburg, it was my wish so to exhibit fishes that they should appear as lifelike as possible. The methods known to me up to that time did not appear favorable, so I began to think of something new. I did not believe fishes should be exhibited in a dry state, — *viz.*, embalmed or stuffed, — nor in tall bottles, standing on head or tail, but that they should be in a horizontal position, seemingly swimming in a medium representing water.

This was attained by means of oblong glass boxes filled with alcohol. It was then observed that the colors which gave the fish a true natural appearance were absent; this was to be helped only by painting, and accordingly an attempt was made with water colors which led to satisfactory results. It has so met the favorable judgment of visitors and professional men that I venture to believe myself in a position to commend this method as worthy of imitation.

In Bergen, Norway, the entire fish fauna has been set up in this way, and is very satisfactory. This method is also in use in the British Museum, as well as in German museums.[1]

The method consists in painting the fish, preserved in alcohol, on one side with water colors, as nearly natural as possible; and then

[1] The paragraphs in smaller type are from letters written to the author by Dr. Brün.

fastening it in a horizontal position by means of gelatin to the wall of the glass box, which is later filled with alcohol. A fish thus successfully prepared appears, to the visitors at least, as a living fish in water. Its lifelike appearance is much improved in the proper painting of the eye, which is not at all difficult. These water colors are durable in alcohol only when they are carefully selected, as has been proved by four (now ten) years' experience. A fish thus completed needs no repairing for some time. While in a general way this method can be recommended, yet in a few instances it may not work, especially when we are dealing with forms that have a bright, sparkling appearance, such as goldfishes. In such cases the Wiese-liquid seems to promise good results. A large goldfish preserved in this liquid for a period of two (now eight) years, though kept in the dark, has lost none of its brilliancy and beauty of color.

The using of oblong glass boxes is more expensive than glass bottles, but when we are dealing with a native fish fauna with comparatively few specimens of considerable size, this evil need not be permitted to play a large part. It is a fact that the mechanical possibilities of producing sufficiently large glass boxes for an available price are limited. The largest glass boxes prepared for this museum are 70 cm. long, and cost 24 marks each. Because of this, only the smaller specimens of the larger species, such as salmon and catfishes, can be easily exhibited. Very large specimens of these can be shown along with the smaller ones, either as mounted specimens or plaster casts, or they may be exhibited in glass boxes, made of glass plates cemented together.

The German marine exhibit in 1896 afforded me an opportunity to demonstrate the fact that these glass boxes with their contents could be easily transported from one place to another. Besides some small ones, the large glass boxes containing the salmon and the lamprey were taken from Hamburg to Berlin and returned in fine condition. The transportation was by boat on the Elbe, but, being taken to and from the boat by wagon, they were subject to considerable jarring.

The task of putting up one of the above-mentioned fishes may be divided into three parts: (1) preparation and preservation; (2) painting; and (3) setting up in the glass boxes.

(1) As the fish must be presented in a swimming position in the glass box with parallel walls, it must be preserved as perfectly as possible. In selecting a specimen one must pay special attention to form, color, proper size. Most of the fishes found in the markets are injured about the mouth, fins, or scales. Pretty badly injured

fins can be repaired. It is always best to select fishes to be mounted at the place of capture, and thus avoid the injuries occasioned by fish dealers in frequently throwing fishes from one vessel to another.

As only one side of the body is exhibited, it should be the better one, though as far as possible, for sake of uniformity, the same side of each should be presented to the visitor, as in my opinion it does not make as good an impression when some fishes are turned to the right and others to the left.

It is advisable to keep the live fish for some time in an aquarium, and make a study of its coloration. Then kill the fish in a 10 per cent solution of alcohol.

In using strong alcohol the mucous layer on the fish becomes too much hardened and cannot be removed.

After one half hour or so the mucous layer can be removed by means of a brush. Next lay the fish on its side in a shallow vessel, the bottom of which is lined with wax, and put on it some stronger alcohol. The fins are then spread, and held in position with insect needles. The torn fins are mended with fine silver wire, which is later removed. After the fish is in its proper position it is hardened by the gradual strengthening of the alcohol; the time required for this depends on the size of the fish, one of about two pounds' weight requiring about six days to bring the alcohol to 75 per cent.

In successful cases the form of the body is scarcely changed at all, and the eye fills its cavity as when the fish was alive. It is well, in case of larger fishes, to inject some alcohol into the vent after killing and to close it with cotton. The intestine should first be pierced, also the inner muscles of the body, with a fine scalpel, that the injected alcohol may fill the body cavity and more easily enter the flesh.

Externally the fish should not be injured in order to make the alcohol penetrate more rapidly, since where injured the fish would not get dry enough to paint, and injury to the farther side would interfere with fastening the fish to the gelatin. Should the belly still sink to an interfering extent, the proper roundness can finally be secured by stuffing it with cotton.

Later I have used formaldehyde 1 : 20, which I believe is to be commended to keep the body shape well. The fish is first killed in weak alcohol, then hardened in formalin, and later transferred to alcohol for permanent preservation. With the formalin treatment the scales of some species come off too easily.

(2) The painting of the fish faded by use of alcohol. For this purpose I have used water ground color and occasionally some marine blue. A few kinds of these colors are, however, to be avoided; in the first place, those containing lead, such as white lead and chrome yellow. The alcohol in which a fish has been for some time finally becomes somewhat acid, and at the same time the process of decomposition forming H_2S turns the colors containing lead dark or black. That is the way I was served in several cases; the pretty white belly of the fish finally appeared quite blackened. Chemical examination of the alcohol showed that there was present .034 per cent of free acid, supposed to be acetic acid (.348 gr. to one liter of alcohol). Under these conditions silver and brass bronze, usually appearing so durable, turned dark. Experiments with $H_2S + H_2O$ resulted in great durability of the same, but changed immediately after any trace of acid was added.

Aluminium bronze remained unchanged, even after the addition of considerable acid. Therefore one should use permanent white fine aluminium bronze and clear gold bronze. For use these are worked with a little liquid gum arabic.

Dr. W. G. Ridgwood has carried out in the British Museum very thorough tests for the most varied colors, as to their permanency in alcohol and sunlight, and has found decided differences.

The method of painting is as follows. The hardened fish is laid on a suitable surface. It is best to color the trunk and head first. In the mean time the fins must not be allowed to dry. The eye should be kept moist before and after painting, else these parts will dry out too quickly and shrink. If after a few minutes the body seems sufficiently dry, then one may begin with the painting, which after a little practice may be done without any special artistic ability. The paint cannot be applied as perfectly as it can be on paper, yet still in a sufficient degree to obtain the desired effect. This is most easily done in case of small scaled fishes, for example the tench; in other cases patience and practice lead to the goal. The process of painting is delayed very much because of one's being occasionally compelled to moisten the parts with alcohol, in order to observe the action of the colors, and eventually to change the tone of the same.

Because of the escape of fat or similar substances, the opercle, and many scales, and fin rays occasionally do not seem to take on the paint. These parts I have endeavored to cleanse with benzine. It

would perhaps be best to give them a coat of ox gall, which is used in painting on glass. The pupil should be colored a bluish black and surrounded with a golden circle verging into the iris; to the iris one can reproduce the niceties of its natural appearance, namely, its silver or gold glint, red circles and spots, black stripes, dots, etc. As soon as the paint is dry the eye should be moistened; otherwise it would sink, though a little sinking is hardly noticeable when the fish is put in alcohol.

Injured fins must be repaired before painting, which may be done by pasting on underside small pieces of silk paper with a thin solution of gelatin. The repaired places must be carefully dried before painting.

(3) The fastening of the fish in the glass.

The glasses used in our museum are blown oblong, with parallel walls. There are three special sizes produced by the glass factories of Gundlach & Müller of Altona-Ottensen. Their comparative sizes in centimeters and their prices, with 5 per cent discount, are as follows:

Length.	Height.	Depth.	Price.
35	20	9	8 marks
50	25	11	11 "
70	30	14	24 "

These glasses are unground: those with polished face are more expensive, but appear also much more elegant. The firm already mentioned has filled many orders for such glasses, and has of course much experience. Transportation of the same, even of the largest glass boxes, has been successfully made to America without material loss.

These glass boxes are closed with sheets of glass about 3 mm. thick and the edges ground to correspond to the thickness of the walls of the box, to which they are securely fastened with gelatin.

The closing of glass boxes, especially the larger ones, is not easy. When the collection is to stand some time undisturbed it is well to close the larger ones by simply covering with the glass lid. As the alcohol slowly evaporates it may be replaced. To open the glass boxes which have been closed with gelatin, it is better to cover the lid with layers of blotting paper and these with a wet cloth. After some time, say over night, the gelatin is softened, and the cover can be released with a little care.

In order to fasten the fish in a horizontal position in the glass case, it should first be laid on its broad side in the manner in which it is to be fastened in the glass. The tail should be supported with a piece of cork, or something of the kind, which is covered with

gelatin. Remove the fish and place where the head is to lay a layer of pretty stiff gelatin liquid, also place some on the cork; then lay the fish, previously well dried, on its unpainted side in its proper position in the glass. Soon the gelatin will be sufficiently hardened to permit the filling of the glass box with alcohol. If necessary, a hot knife may first be applied to the gelatin to fasten the fish securely to the glass. An eight-pound salmon fastened in this way has remained unchanged. The visitor sees nothing of this manner of fastening.

As I have in the foregoing only spoken of the painting of fishes, I should here like to say that other objects to be kept in alcohol may be treated in the same manner, — reptiles, amphibians, invertebrates, anatomical preparations, plants, etc.

In our museum at Hamburg there are numerous painted objects of this kind from both fresh and salt water, and though very imperfectly painted, they have a lifelike appearance. Especially is this true of water plants.

Such objects as sponges, which should have a uniform coloring, and which will stand being in water for a little while, may be put into a watery solution of the color, where they quickly become impregnated with it.

Moulded glass vessels are not as perfect as they should be; the surface is not exactly smooth; besides, it is made more or less dim by being in contact with the mould. The glass is thicker at the center and gradually thins out toward the edges and corners. The side of an oblong moulded glass vessel is quite inferior to a similar surface of polished plate glass. It is not necessary that a vessel be made entirely of glass; the top, bottom, two ends, and farther side may as well be made of any other suitable material. The side through which the observer must see the specimens cannot be too perfect.

A few years ago Mr. J. E. Benedict, of the United States National Museum, appreciating the value of a glass vessel whose sides (front one at least) are planes, experimented considerably, constructing vessels by cementing together sheets of plate-glass. To what extent he now regards this method as a success I am not advised. I never did believe his method received the recognition it deserved. It seems to me, however, that by using this method, the exhibition surface must necessarily be limited,

just as in the case of the cast-glass boxes. The idea of representing a fish in a museum in a fluid so that it "appears, to the visitor at least, as a living fish in water" is an excellent one. Following out this idea, our exhibition vessel partakes somewhat of the nature of an aquarium. A well-constructed aquarium needs but one glass side, and this side should be polished plate glass. It is necessary to make a joint between the material used and the plate glass which will not be effected by changes of temperature, and this presents no serious difficulties.

We have not tried the painting of fishes or fastening them in the vessel by means of gelatin. The use of round or oval glass bottles has been, within the past few years, quite universal. But both of these bottles are objectionable, because in them the fishes must stand on head or tail, and besides suffer more or less distortion. Among fishes are many peculiar and interesting forms, and this class of animals are as deserving of suitable methods of exhibition as are the other classes.

The time has certainly come when some method which will permit fishes to be placed in our museums as lifelike as possible, and one which will be economical and durable, will be much appreciated. If those who are interested in this question, and who have given it some attention, will publish the results of their experiments, it is possible that enough good features can be selected to discover the proper method.

NOTES AND LITERATURE.

GENERAL BIOLOGY.

Jenkins and Kellogg on Nature Study. — Under the title of *Lessons in Nature Study* Professors Jenkins and Kellogg of Stanford University have issued a volume (Whitaker & Ray, San Francisco) which should be of great service to teachers. It contains simple directions for the study of natural objects within reach of children. Among these are the dandelion, the mosquito, the toadstool, pond insects, spiders, crystals, ferns, birds, etc. These lessons are based on actual experience in dealing with children. The book is well illustrated and fairly printed.

D. S. J.

ZOÖLOGY.

"Bird Watching" [1] is the modest title of a new volume in the Haddon Hall Library. There are a dozen chapters, dealing with a variety of British birds, and constituting a record of patient "watching" of great plover on open, sandy wastes; wheatears on warren lands; great skuas and shags on far northern islands; winter birds at a straw stack, etc. The account of the actions of these and other birds often takes the form of long extracts from the author's notebook, but his personality and feeling for style give his observations an unusually bright and readable character. Occasionally he pushes his fancies to the verge of extravagance, and frequent digressions increase the burden of legitimate detail which the reader willingly bears. While there is constant evidence of painstaking accuracy of statement, the author's interest in the problems connected with the evolution of habit and plumage tempt him often into rather fruitless speculation.

The book must be very welcome to the lovers of British birds and will be read with interest not only by American ornithologists but

[1] Selous, Edmund. *Bird Watching.* The Haddon Hall Library. London, J. M. Dent & Co., 1901. 8vo, x + 347 pp., 14 illustrations.

also by many of the growing class of amateur naturalists. Detailed observation of familiar birds (such as Mr. Frank Bolles's paper on "Sap Suckers") will constitute an ever-increasing proportion of the literature of our popular ornithology, which has hitherto been marked by the not unnatural tendency to magnify the importance of a new or unfamiliar species.

The paper, print, and binding are extremely attractive. There are fourteen full-page drawings by J. Smit. These drawings, if necessarily less accurate than the now omnipresent photograph from nature, possess a welcome softness and repose.

R. H.

A New Economic Entomology.[1] — In a neat little volume of about three hundred pages, Prof. H. Kolbe has compiled an admirable treatise on *Gartenfeinde und Gartenfreunde;* it constitutes Vols. XXXIV–XXXVI of the great German "Garten-Bibliothek." This little venture of the author into the economic field will be of interest to American entomologists, as we are familiar with his great work, *Einführung in die Kenntnis der Insekten.* Notwithstanding the wealth of German literature on injurious insects and plant diseases, *Gartenfeinde und Gartenfreunde* fills an unoccupied niche, for it deals with both the animal (principally insects) and fungous enemies in a way suited to the needs of every German gardener.

After a brief discussion of the structure, the classification, and the various groups of insects, a dozen pages are devoted to remedial and preventive measures. Here the author introduces some of our American methods, but it is evidently unfamiliar ground. Sirrine's poisoned-resin mixture is recommended for garden caterpillars, and the Bordeaux mixture for nearly all fungous diseases; but our kerosene emulsion he calls "petroleumbrühe," and under "kerosene emulsion" he gives the formula for our potash whale-oil soap. Among remedies for plant-lice and thrips he mentions Paris green used dry. It is also an interesting fact that nowhere else in the book are any of our arsenical or other poisons recommended for killing insects; currant worms are to be shaken off onto a sheet instead of poisoned, and the universal poison spray of American orchardists for the codling-moth and other caterpillars is not mentioned. Most of the remedial measures involve hand work. The discussion of preventive measures is excellent, and the chapters on state, communal, and social

[1] Kolbe, H. *Gartenfeinde und Gartenfreunde. Die für den Gartenbau schädlichen und nützlichen Lebewesen.* Garten-Bibliothek, Bd. xxxiv–xxxvi. Berlin, Karl Sigismund, 1901. 8vo, iii + 318 pp., 76 figs.

institutions and regulations relating to plant protection in different countries will interest American readers.

The admirable method is followed of discussing the enemies under their respective food-plants, and over sixty pages are devoted to fruit-tree enemies. The San José scale receives more space than any other enemy except the grape phylloxera, and curiously enough the *Aspidiotus ostræformis* scale is called the "yellow European pseudo-San José scale." Injurious mammals and birds are briefly discussed, and then fifty pages are devoted to "Gartenfreunde," mostly the parasitic and predaceous insects.

I know of no similar work in any language covering so much ground so briefly and yet so well adapted for its field.

M. V. S.

The Circulation in the Nervous System. — In a pamphlet of some hundred and fifty pages bearing the above title, Dr. Gasser[1] develops what to his mind "is the only true conception that is in entire harmony with the established order of facts in the world of thought" concerning the action of the nervous system. Precisely what this conception is the author nowhere makes very clear, but so far as can be gathered his experience as a physician has profoundly impressed him with the belief that the nervous system works in a circular fashion. What circulates, whether matter or energy, and through what particular channels the circulation is accomplished, is left mostly to the imagination of the reader, though we are told that the evidence for this movement is as substantial as that for the circulation of the blood. As a figure of speech the circulation in the nervous system may be innocent enough; as a description of what actually takes place it is utterly without foundation. P.

The Oarfish, Regalecus, on the Coast of Southern California. — On the 25th of February a huge "sea serpent," with bright colors and the conventional mane, was reported in the newspapers as having come ashore near Santa Ana in southern California. No part of the animal was preserved, so far as known, but a good photograph was taken by Mr. G. T. Peabody of Santa Ana. It evidently represents an oarfish or herring king, some species of Regalecus. The fish was fifteen feet long and something over a foot in depth, weighing about five hundred pounds. The dorsal is considerably injured,

[1] Gasser, H. *The Circulation in the Nervous System.* Plattville, Wis., Journal Publishing Company, 1901. 156 pp.

but as nearly as can be counted the number of rays is about four hundred. The long spines on the head do not show in the picture. The species of Regalecus have never been defined, and the present one can hardly be certainly identified. It may be the New Zealand-Japanese-Indian species, *Regalecus russelli* or *argenteus*. D. S. J.

Notes on Recent Fish Literature. — In the *Annotationes Zoologicæ Japonenses* (Vol. IV, Pt. I), Dr. S. Hatta has a review of the Japanese lampreys, with notes on their local distribution and their anatomical structure. The new species, *Lampetra mitsukurii* Hatta, already characterized by Dr. Jordan, is here described. In another note Dr. Hatta discusses the metameric segmentation of the mesoblast in the lamprey and the lancelet. In the earlier stages the segmentation in the lamprey agrees with that of the lancelet ; in its later stages with that of the higher craniota.

In the *Atti de la Società di Naturalisti*, etc., of Modena, Dr. Luigi Facciolà continues his valuable series of studies of the development of the larvæ of different forms of eels. These larvæ, known as Leptocephali, are ribbon-shaped, translucent, and soft, with very small heads. In their further development they undergo a shrinkage in size, attaining greater compactness of substance.

In the *Proceedings of the United States National Museum* (Vol. XXIV, pp. 33–132), Jordan and Snyder continue their series of monographic reviews of the fishes of Japan. Of the gobies, 57 species are described, representing 33 genera. Of these species, 21 are new and are here represented in the excellent drawings of Mrs. Chloe Lesley Starks.

We may here note that the generic name Chasmias, proposed by Jordan and Snyder for a genus of gobies in 1900 (page 761), is antedated by Chasmias Ashmead, a genus of Ichneumon flies published on page 17 in the same volume of the *Proceedings*. The genus of fishes, type *Chasmias misakius*, may receive the new name of Chasmichthys Jordan and Snyder. I am indebted to Mr. W. H. Ashmead for calling attention to the prior establishment of his genus. Of sea horses, pipefishes, and their relatives, nineteen species are described from Japan. Of these, seven are described and figured as new. The sea horses exist in especially large number and variety along the headlands washed by the warm "Black Current," or "Kuro Shiwo."

Professor Gilbert L. Houser, of the University of Iowa, contributes to the *Journal of Comparative Neurology* (Vol. XI, No. 2) a valuable monograph on the "Neurones of a Selachian," *Mustelus canis*. The anatomy of the nerve structures is given in great detail. Professor Houser shows commendable caution in refraining from "the tendency to elevate the results of specific methods into exclusive dogma." He closes his paper with these remarks suggestive of Golgi: "The knowledge which we possess, either anatomical or physiological, is not yet such as to permit us to interpret with certainty the greater number of the facts discovered, much less to attempt doctrinal constructions of a high order on the functional mechanism of the nervous elements."

In the *Bulletin of the United States Fish Commission* Dr. Eigenmann gives a useful account of the development of certain eggs supposed to be those of the Conger.

In the same *Bulletin* Dr. Hugh M. Smith gives a list of species of fishes the young of which are borne to Woods Hole in the Gulf Stream. Four of these, *Exonautes rondeleti*, *Ocyurus chrysurus*, *Scarus croicensis*, and *Sparisoma flavescens*, had not been previously recorded to the north of Florida. Among the other tropical forms are *Sardinia pseudohispanica*, *Mycteroperca bonaci*, *Mycteroperca venenosa*, *Lutianus apodus*, *Lutianus analis*, *Chætodon ocellatus*, *Chætodon bricei*, *Teuthis cæruleus*, *Teuthis hepatus*, *Teuthis bahianus*, *Lactophrys tricornis*, and *Scorpæna plumieri*.

In the *Annotationes Zoologicæ Japonenses* (Vol. III, Pt. IV), Dr. C. Ishihawa describes and figures two new gudgeons, *Leucogobio güntheri* and *L. jordani*. Both species belong to the rich fauna of Lake Biwa, the largest lake of Japan.

In the *Proceedings of the United States National Museum* (Vol. XXIV) Jordan and Starks give an account of the anatomy of Aphareus, a Polynesian genus of "red snappers," rare in collections.

In the *Proceedings of the United States National Museum* (Vol. XXIV) Jordan and Starks give an account of the Atherinidæ, or silver-sides, found in the waters of Japan. Five species are enumerated, four of them being new. Two new genera, Atherion and Iso, are characterized.

D. S. J.

Zoölogy of the Maldive and Laccadive Archipelagoes. — The results of the explorations of J. Stanley Gardiner in the Maldive and

Laccadive archipelagoes of the Indian Ocean[1] are appearing in a series of parts that closely resembles the series of Willey's "Results." The first part contains an eleven-page "Narrative and Route of the Expedition," with two maps. This shows that one who goes on such a journey may expect exasperating delays of weeks at a time. Next follows "An Account of the Coral Formations of the Indian Ocean," by Gardiner, which is not completed, but shows that atolls have been formed in regions of *elevation* (and not always of depression, as called for by Darwin's theory). The accompanying papers are by Borradaile (who was with Gardiner in the early part of his trip) on the "Land Crustaceans"; by Cameron on "Hymenoptera"; and by Punnett on "Nemerteans." In the last paper the first mesonemertean from the Indian Ocean is recorded, — a Cephalothrix. The prevailing genera are Eupolia, Cerebratulus, and Drepanophorus, — genera widely distributed. As to the Hymenoptera, Cameron says the known species are Indian forms of wide distribution in the Oriental zoölogical region, and all the genera are of universal distribution in temperate and tropical countries, — such familiar genera as Crabro, Bembex, Polistes, and numerous Apidæ. The most general interest attaches, however, to the paper on "Land Crustaceans." "Their numbers, their ubiquity, their activity, combine to give them a prominence which is all the more marked from the absence of so many other land animals of continental areas. They are the chief scavengers of the island, play a great part in the destruction or disintegration of fruits, and probably aid in the distribution of seeds. The work done by them in burrowing along the sandy lagoon shore has a possible importance not hitherto noticed." The paper gives an exhaustive account of the anatomy of Cœnobita, the land hermit crab. The gills seem to have undergone little modification, and the gill chamber is not at all a lung, but provision is made for keeping the gills moist by means of salt water apparently retained from possible rare visits to the sea. If this salt water is removed, a sticky fluid is exuded over the gills. If the gills be cut off, the crab lives by virtue of its abdominal respiration. Continuous submersion is fatal after a longer or shorter time, — one to six days. The habitation of the land hermit crab is very varied, — usually any kind of land or sea gastropod shell;

[1] Gardiner, J. Stanley (editor). *The Fauna and Geography of the Maldive and Laccadive Archipelagoes*, being an account of the work carried on and of the collections made by an expedition during the years 1899 and 1900. Vol. i, pt. i, Pls. I–V, text-figs. 1–23. Cambridge, University Press; London, C. J. Clay & Sons, 1901. Price 15*s*.

but also a serpulid worm tube, a half cocoanut shell, and a broken glass tube were appropriated. Ocypoda occurs here in two species, one of which lives and burrows in the sand, the other inland. Three grapsids are found ; two Palæmonidæ, a Ligia, four Oniscidæ, and one of the Armadillidiidæ.

Recent Sporozoan Investigations.[1] — This pamphlet, which is a revision and expansion of the articles published in the *Centralblatt für Bakteriologie* (Bde. XXVII and XXVIII), gives not only the most extensive, but also the fullest and most reliable, discussion of present knowledge on this group, which has been almost neglected until the appearance of recent studies on its structure and development. The chapters of Lühe's work take up the life history (1) of the Coccidia, (2) of the Hæmosporidia (malarial parasites), (3) of the Gregarinida, Myxosporidia, and the little-known groups of Microsporidia, Sarcosporidia, and Haplosporidia. The first two sections are particularly complete and satisfactory, and it is hard to find omissions, while the discussion of the various authors cited is admirably fair. The comparative table of terms used by different writers in describing the development of Coccidia will prove very useful in view of the entire lack of uniformity as to terms employed, — a defect so universal that even successive publications of the same investigator differ in terminology. Much would be gained by the adoption of a uniform set of terms as advocated by Lühe, but unfortunately the papers which have appeared since his have added to the confusion by making further changes.

The third chapter is the least satisfactory, probably, since the field covered by it is the least well known and is consequently most difficult to bring into relation with the other groups. Furthermore, the introduction of numerous additions to the original articles, in the form of lengthy footnotes and appendices, makes the treatise difficult to use at some points; and yet the gain in accuracy compensates for the slight lack of clearness.

In one point the work must be strongly criticised: the bibliographic methods employed are antiquated and cumbersome to an extent that interferes greatly with the clearness of the text. One may well wonder how the author could have done so well with such a confused system of reference, the same papers, *e.g.*, Labbé, "Sporozoa," being referred to in three different literature lists by as many different numbers.

[1] Lühe, M. *Ergebnisse der neueren Sporozoenforschung.* Jena, 1900.

Lühe is nevertheless to be congratulated on having produced the first manual on the entire group, and in having made it a well-balanced and useful treatise.

H. B. W.

Notes. — Under the name of *Causeries Scientifiques*, the Zoölogical Society of France began last year the publication of a series of lectures on various topics of scientific importance. Among the subjects treated thus far are "Vibratile Cilia," by P. Vignon; the "Tectibranch Mollusks," by J. Guiart; and "Coccidia and their Pathogenic Rôle," by R. Blanchard. While the method of treatment shows all the advantages given by the freedom of a lecture and the articles are very readable, they are not lacking in scientific accuracy.

Stiles and Hassall (*Annual Report of the Bureau of Animal Industry* for 1899) have described carefully the mammalian lung fluke recorded previously from dog and cat in the United States and believed to be identical with the Asiatic lung fluke of man. The parasite is reported as frequent in the lungs of hogs slaughtered in Cincinnati, and the authors are inclined to regard it as identical with the Asiatic form, and hence as a real menace to the health of man in this country as it is in Asia.

Braun has added to his previous studies on the trematodes two further articles. The first, on the trematodes of the chelonians (*Mittheil. Zool. Mus. Berlin*, Bd. II, 1901), deals with twenty-two species in detail, the large majority of which are new or poorly known forms. The second paper, on the trematodes of mammals (*Zool. Jahrb.*, Syst., Bd. XIV, 1901), discusses thirteen forms, chiefly also from the Berlin collection. Noteworthy is the demonstration of the specific difference between *Opisthorchis tenuicollis* Rud. and *O. felineus* Riv., which have recently been thrown together by a number of authors. The careful comparisons between related species instituted by Braun in these studies furnish the only hope for the clearing up of this much-confused territory.

Among the parasites from Lake Nyassa recently described by von Linstow (*Jenaische Zeitschr.*, Bd. LIII, p. 408), *Tænia africana* n. sp., from man, and *Moniezia amphibia* n. sp., from the hippopotamus, are noteworthy.

The embryonic development of Anoplocephala has been worked out in detail by Saint Remy (*Arch. Parasitol.*, Vol. III, p. 292), who has observed for the first time in this group the formation of polar corpuscles.

The life cycle of the gregarines has been studied by Cuénot (*Arch. Biol.*, Vol. XVII, p. 581). He finds that the conjugation of the sporoblasts is a regular feature of the encysted condition.

Shipley has given (*Quart. Journ. Micr. Sci.*, Vol. XLIV, p. 281) an account of the structure of *Syndesmus echinorum*, an imperfectly known turbellarian which parasitizes in the sea urchin.

Loxosoma davenporti, which is described by Nickerson (*Journ. of Morph.*, Vol. XVII, p. 351), is the first representative of this genus to be recorded from this continent.

Klunzinger has published (Stuttgart, 1901) a valuable discussion on the physical, chemical, and biological causes of color in bodies of fresh water.

Elrod has published (*Trans. Amer. Micr. Soc.*, Vol. XXII, 1901) an extended account of the work done at the Montana Biological Station, Flathead Lake, during 1899. The paper gives a full description of the region, and lists of some collections made at different points, with a few striking features in the distribution of such forms as have been studied. The nine plates are good illustrations of the general appearance of the region.

Fordyce has worked up (*Trans. Amer. Micr. Soc.*, Vol. XXII, 1901) the Cladocera of Nebraska. The paper gives a valuable summary of our knowledge of the distribution of these forms in the United States, and a discussion of the conditions in the plains region, and then records important notes on the vertical distribution of species in small lakes. In all, twenty-six species were found, of which five — *Macrothrix tenuicornis*, *Dunhevedia setiger*, *Bosmina obtusirostris*, *Daphnia curvirostris*, and *Chydorus rugulosus* — are rare in the United States; *Pleuroxus truncatus* has not yet been recorded elsewhere from this country; and three — *Daphnia parvula*, *Bosmina ornamenta*, and *Leydigia fimbriata* — are new to science; descriptions and figures are given for these and the rarer forms.

There has been received through the courtesy of Dr. Mitsukuri a copy of a work entitled "Classified Catalogue of the Specimens of Vertebrates in the Collections of Kiyoiku Hakubutsukuan (Educational Museum)," published in Tokyo in 1881 by Motokichi Namiye, now curator in the Imperial University of Tokyo. The work is especially interesting as the earliest contribution of the Japanese (known to me) to the systematic zoölogy of their country. It gives a list of

1180 species of vertebrates, systematically arranged, with the vernacular names of each species. The identification is made from standard authorities and is generally correct, reflecting much credit on the patience and conscientiousness of its author, Mr. Namiye.

R. Lauterborn (*Zool. Anzeiger*, Bd. XXIV (1901), pp. 50–55) has found that shallow fresh-water ponds covered with such floating plants as duckweed, and with bottoms of black vegetable ooze often generating hydrogen sulphide, contain a very uniform and characteristic life. The flora is mostly sulphur bacteria, the almost complete absence of desmids and diatoms being very striking. The fauna contains, in addition to certain rhizopods and flagellates, no less than eighteen exclusively characteristic species of Infusoria. The author proposes to call this well-defined fauna and flora sapropelic, because of its association with decaying mud.

BOTANY.

A New Work on Gymnosperms.[1] — This is a very welcome addition to the list of books dealing with the special morphology of the higher plants.

The last five years have been notable for the number of important contributions to our knowledge of the Gymnosperms, and these recent discoveries have very materially changed the older views as to the affinities of some of them, notably the Ginkgoales. The book before us summarizes, very successfully, the results of these investigations, and should be very much appreciated by all botanical students.

While the book is largely a compilation, it includes some original work, especially in the illustrations, many of which are exceptionally good.

The book deals principally with the reproductive parts, which are treated very much in detail. While the writer agrees with the authors that an elaborate discussion of the vegetative organs was impracticable in a book of this character, still the value of the book would have been much enhanced by a proper treatment of the more

[1] Coulter, J. M., and Chamberlain, C. J. *Morphology of Spermatophytes.* New York, Appleton, 1901. 8vo, x+188 pp., 106 figs.

important anatomical characters of the vegetative organs of the principal groups. This is especially the case in regard to the apical meristems. A single borrowed figure (Fig. 48) is hardly sufficient to make clear the characters of the apical meristems of the whole group.

Four coördinate series of living Gymnosperms are recognized, *viz.*: Cycadales, Ginkgoales, Coniferales, Gnetales. These are considered successively, the details of the gametophyte and embryo being treated very completely. On the whole, the treatment of the Cycads and Ginkgoales is most satisfactory, although including less original matter than the chapter on the Conifers. The important work of Webber, Lang, Ikeno, and Hirase are given full attention, and the chapters are fully illustrated by numerous well selected and well executed figures.

The chapter on the Conifers is to a great extent a study of *Pinus laricio*, presumably the work of the junior author. This is very complete and admirably executed. It is to be regretted, however, that the author did not include some of the numerous important American types as well as the highly specialized genus Pinus. The work hitherto done upon the genera Taxodium, Sequoia, Torreya, Thuja, etc., is very incomplete, and the inclusion of these in the book would have been a real contribution to the literature of the subject. As it is, the chapter on the Conifers must be considered much less satisfactory than those upon the other orders.

The later chapters treat very satisfactorily the fossil Gymnosperms, comparative morphology of Gymnosperms, phylogeny and geographical distribution. A valuable feature in the chapter upon the fossil forms is a series of photographs illustrating some of the Mesozoic Cycads of the United States.

The conclusions as to the origin and affinities of the Gymnosperms are essentially the same as those given by Professor D. H. Scott in his recent work on fossil plants, *i.e.*, all of the existing Gymnosperms are referable to a common ancestral stock, of filicineous origin. This conclusion, we surmise, will not be admitted, without reservation, by all botanists.

The illustrations are, for the most part, extremely good. Some of the half-tone figures, however, such as the sections of leaves shown in Figs. 5 and 47, are too blurred to have much value, and might well be replaced by good line drawings.

An admirable feature of the book is the carefully prepared bibliographies at the end of the chapters.

The book has a distinct place, and ought to be very welcome, both as a work of reference and as a stimulus to further work in this important group of plants, which are so well represented in our own flora.

D. H. C.

MacDougal's Plant Physiology.[1] — Those who have had occasion to feel the lack of a clear, concise, and up-to-date text in plant physiology will welcome the appearance of any promising book on this subject. Dr. D. T. MacDougal, of the New York Botanical Garden, is the author of a work of this character.

Dr. MacDougal points out in his preface the increased recognition of irritability in its various manifestations, due chiefly to the work of Pfeffer, and makes this the cardinal point in his arrangement of the subject-matter. The first seven chapters are devoted to a consideration of this subject in its different phases. The study of these functions and properties, or the organism and its interaction with environmental conditions, is thus the first task of the student. The composition of the plant body, exchange and movements of liquids, metabolism, growth and reproduction, are taken up in the order named. To some this order of consideration may seem open to question on the ground that the student is plunged immediately into the thick of the most obscure of plant activities, where he can find little by way of physical or chemical foundation to lend him support.

In general, the treatment of the different phases of the subject of irritability is very satisfactory. One notes with pleasure that recent work has been incorporated. A sense of being in touch with the movement of the science is worth not a little as a stimulus to the student. This prompt acceptance, however, in an elementary text, of work that has not been thoroughly verified, unfortunately has its possible disadvantages. Occasionally, without criticising a given piece of work, one hesitates to accept the author's statement of results without a grain of salt. Explanations, even though plausible, may rightly fail to win unreserved adherence until more evidence is at hand. The work of Nemec on transmission of stimuli, Loew's explanation of the action of various classes of poisons, and (in another part of the book) Nathansohn's amitotic nuclear division under the circumstances reported, illustrate the principle just enunciated. In some cases, through oversight, minor errors have crept

[1] MacDougal, D. T. *Practical Text-Book of Plant Physiology.* London, Longmans, Green & Co., 1891. 8vo, 352 pp., 159 figs.

in. The strong mineral acids in normal solutions are by no means completely dissociated in all cases (p. 53). A "normal solution" as defined in botanical literature should conform to the chemical usage (p. 51). Unfortunately, in a number of instances botanists have failed to be thus exact in the use of terms, and confusion is likely to follow. These matters will doubtless correct themselves in later editions of the book under discussion.

The chapter dealing with the composition of the plant body, written by Mr. J. E. Kirkwood and Dr. W. J. Gies, introduces the beginner to the methods of detecting and estimating many of the more important substances that may be extracted from plants. This chapter will probably prove very useful, since it furnishes in clear, brief terms much information to which the student will be glad to refer often. The chapters dealing with the chemical changes taking place in the plant, with growth and with reproduction, call forth much by way of commendation.

In view of the fact that the book is intended to contain "details of experimental methods suitable for the exact analyses requisite in research work," it demands notice as a laboratory guide. The experiments are closely interwoven throughout the book with the discussion of the various phases of the subject which they illustrate. Generally speaking, the experiments are abundant and well chosen, and the directions for work are couched in clear terms. In the manner of arranging this matter, one might perhaps see some grounds for question. The juxtaposition of experiment to principle illustrated aids a possible shrewd guess on the part of the student occasionally, but the author has generally avoided undesirable suggestion in describing the experiments. Of course, this intermingling of discussion and experiment makes the book more difficult of use as a work of reference.

As a whole the illustrations are good, whether original or borrowed. An occasional exception may be noted (Fig. 134).

An appendix contains numerical data of use to the laboratory student. Tables for converting units of various kinds into those of other systems, densities of gases, expansion of air at different temperatures, and an abridgment of Pfeffer's table of osmotic values may be mentioned.

The book has so many excellencies that it is entitled to a wide use, and the occasional errors will be remedied as later editions call the author's attention more critically to his text. R. H. T.

Ganong's Plant Physiology.[1] — Notwithstanding the recognized importance of plant physiology as a source of illuminating information on the conduct of living things, as well as a valuable means of discipline, the very scanty assortment of English texts available for classes taking up this study has been a source of inconvenience to many teachers. Laboratory manuals and concise, up-to-date treatises on the subject have both been conspicuously lacking.

Fortunately, several additions to our texts on this subject have recently been made; among these *A Laboratory Course in Plant Physiology*, by Prof. W. F. Ganong of Smith College (New York, Henry Holt & Co., 1901), outlines a series of experiments covering a school year in which eight hours are given weekly for laboratory work. Dr. Ganong has chosen experiments for their teaching value, making use of those, so far as possible, which require simple apparatus, purchasable at small expense. Inspection of the figures and descriptions given discovers much ingenuity in this selection. Since Dr. Ganong believes that in elementary courses "it is mainly qualitative results that are of value," although "the exact quantitative methods and spirit are scientifically and educationally the best," the correct use of simple apparatus is emphasized. Comment upon the experiments is chiefly by the way of suggesting to the student lines of thought and reading. When experiment is out of the question proportion is secured by references for outside reading. Much use of synoptical essays is recommended.

The suggestions are, in most cases, stimulating and within the range of the possible. When, however, the student is directed to form a clear mental picture of the molecular processes and energy involved in osmosis, one cannot refrain from asking whether the picture is to be that in the mind of Graham or that in the mind of van't Hoff. When physicists are still divided on the subject the undergraduate deceives himself who fancies that he has the data necessary for the formation of a clear mental picture.

The book is clearly the result of careful work and ample experience. It cannot but be of the greatest assistance to the teachers of plant physiology, and it deserves to be most cordially received.

R. H. T.

Notes. — Part I of a botany of the Faeröes, based upon Danish investigations, has been published, by aid of the Carlsberg fund, by

[1] Ganong, W. F. *A Laboratory Course in Plant Physiology, especially as a Basis of Ecology.* New York, Henry Holt & Co., 1901. 8vo, vi–146 pp., 35 figs.

the Nordiske Forlag of Copenhagen. Dr. Warning contributes the historical introduction, and systematic and ecological discussions are given of all but the marine algæ, which, with a comparison of land and sea vegetation and certain economic discussions, is reserved for a concluding part.

The Congo Museum of Brussels has commenced the publication, as a series of its *Annales*, of a systematic enumeration of the Congo plants collected in 1895–96 by Dewèvre. The descriptions are by De Wildeman and Durand.

Some botanical matter of interest to students of our northern vegetation is contained in No. 21 of *North American Fauna*, referring to the natural history of the Queen Charlotte Islands and the Cook Inlet region.

The willows of Alaska are discussed by Coville in the *Proceedings of the Washington Academy of Sciences*, under date of August 23.

Part VI of Dr. Rydberg's "Studies on the Rocky Mountain Flora," in the September *Bulletin of the Torrey Botanical Club*, contains a considerable number of new species, chiefly gamopetalous.

A second part of Barber's "Flora der Oberlausitz" is contained in Vol. XXIII of the *Abhandlungen der Naturforschenden Gesellschaft zu Görlitz*.

Professor Arechavaleta's flora of Uruguay, in course of publication in the *Anales del Museo Nacional de Montevideo*, has reached the group Mimoseæ.

A number of papers on the phanerogamic flora of Java, by Koorders, are contained in Vol. LX of the *Natuurkundig Tijdschrift voor Nederlandsch-Indië*.

The holly-leaved barberries, constituting the genus Mahonia, are revised by Fedde in the opening number of Vol. XXXI of Engler's *Botanische Jahrbücher*, which also contains a monograph of the orchid group Diseæ, by Schlechter.

The signatures of Vol. IV of *Pittonia*, issued September 30, contain descriptions of a number of violets and crucifers, by Professor Greene.

The origin of Liriodendron stipules is discussed by E. W. Berry in the *Bulletin of the Torrey Botanical Club* for September.

Hybrid currants are discussed by Janczewski in the July *Bulletin International de l'Académie des Sciences de Cracovie*.

A monograph of the genus Sorbus, by Hedlund, is reprinted from Vol. XXXV of the *K. Svenska Vetenskaps-Akademiens Handlingar.*

The chemistry of the bark of *Robinia pseudacacia*, by Power, and the anatomy of the bark of the same species, by Perrédès, form the subject of Nos. 20 and 21 of the *Publications of the Wellcome Chemical Research Laboratories* of London. A paper by von Schrenk, on the decay of the wood of the same tree, induced by *Polyporus rimosus*, has been separately printed from the *Twelfth Report of the Missouri Botanical Club.*

Dr. Heyl, of Darmstadt, has distributed a paper, "Ueber das Vorkommen von Alkaloiden und Saponinen in Cacteen," from the June Heft of the *Archiv der Pharmazie. Pilocereus sargentianus, Cereus pecten-aboriginum*, and *C. gummosus* were studied.

Professor Hume publishes an interesting account of *Citrus decumana* as *Bulletin 58 of the Florida Experiment Station.*

Aligera patelliformis and *Collinsia breviflora*, from California, are described in *The West American Scientist* for August, by Suksdorf.

Agave langlassei is the name applied by André, in the *Revue Horticole* for August, to a species of Manfreda from the Pacific slope of Mexico.

Professor Nelson publishes an economic treatise on the species of Bromus occurring in Wyoming, in *Bulletin No. 46 of the Wyoming Experiment Station.*

In a paper published as No. 3 of the current volume of *Proceedings of the California Academy of Sciences* Professor Peirce discusses the curious etiolated suckers which are sometimes produced by *Sequoia sempervirens.*

Separates of a paper on hybrid conifers, by Dr. Masters, have been distributed from the *Journal of the Royal Horticultural Society.*

Dr. E. F. Smith publishes an extended account of the cultural characters of four species of Pseudomonas of economic importance, in *Bulletin No. 28 of the Division of Vegetable Physiology and Pathology of the United States Department of Agriculture.*

In a paper reprinted from the *Proceedings of the Indiana Academy of Science* for 1900, Professor Arthur reaches the conclusion that the "cedar-apple" fungi, usually known by the generic name Gymnosporangium, should really be called Tremella, and he consequently

renames them under this genus, — without, however, considering the nomenclature of the many fungi usually treated as constituting the latter.

A revision of North American puffballs of the group Tylostomaceæ, by V. S. White, appears in the *Bulletin of the Torrey Botanical Club* for August.

A revision of the genus Tilletia, by Massee, is contained in the Kew *Bulletin of Miscellaneous Information* for 1899.

Professor Bailey contributes to *The World's Work* for September an illustrated account of Luther Burbank's work as a plant breeder.

Current numbers of the *Revue Générale de Botanique* contain a treatise by Jumelle on the rubber plants of northeastern Madagascar.

Raphia bast, much used by florists, is considered at length in a paper by Sadebeck, reprinted from Vol. XVIII of the *Jahrbuch der Hamburgischen Wissenschaftlichen Anstalten.*

An illustrated paper on the anatomy of the cocoanut, by Winton, is published in the October number of *The American Journal of Science.*

The weeds of Montana are treated by Professor Blankinship in *Bulletin No. 30* of the Experiment Station of that state.

Dr. Willis, director of the gardens, has begun the publication of an irregular-period journal under the title *Annals of the Royal Botanic Gardens, Peradeniya.* The first number, issued in June last, contains a brief history of the gardens and an account of the facilities offered for research.

Volume VIII of the *Proceedings of the Iowa Academy of Sciences* contains the following botanical articles: Graw, "Preliminary List of the Flowering Plants of Adair County": Fitzpatrick, "Juglandaceæ, Betulaceæ, and Fagaceæ of Iowa"; Mueller, "Shrubs and Trees of Madison County"; Pammel, "Thistles of Iowa, with notes on a few other species"; Faurot, "Notes on the Early Development of *Astragalus caryocarpus.*"

The initial numbers of the *Bulletin du Jardin Impérial Botanique de St.-Pétersbourg* are largely concerned with fungi and lichens. The Russian text is accompanied by abstracts in French.

An account of the Geneva meeting of the newly organized Association Internationale des Botanistes is printed in the current volume of the *Bulletin de l'Herbier Boissier.*

The World's Work for September contains an illustrated account of the Arnold Arboretum, by Sylvester Baxter.

A little handbook of nature-teaching based upon the general principles of agriculture, by Francis Watts, has been prepared at the wish of Commissioner Morris, of the Imperial Department of Agriculture for the British West Indies, and is printed by Messrs. Dulau & Co., of London.

Some phases of the conflicting interests of people who are trying to teach city pupils about nature, and those who are trying to preserve natural objects, are well presented in an article by Mrs. Britton in *Torreya* for August.

A suggestive essay entitled "How shall a Young Person study Botany?" by Professor Beal, is reprinted from the *Proceedings* of last winter's conference of the New York State Science Teachers' Association.

Another of the interesting and well illustrated memoirs on plant ecology that the *Botanical Gazette* is bringing out is by Professor Bray, and deals with western Texas.

Phytogeographic nomenclature, discussed by Flahault in the July *Bulletin of the Torrey Botanical Club*, was the subject of an extended paper by Clements at the recent Denver meetings.

A paper on some changes effected in plants by frost is published by Lapeyrère in the current volume of the *Bulletin de la Société de Borda*, of Dax.

An essay on old herbaria, by Matouschek, is printed in Vol. XXXII of the *Mittheilungen aus dem Vereine der Naturfreunde in Reichenberg* for 1901.

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(Regular exchanges are not included.)

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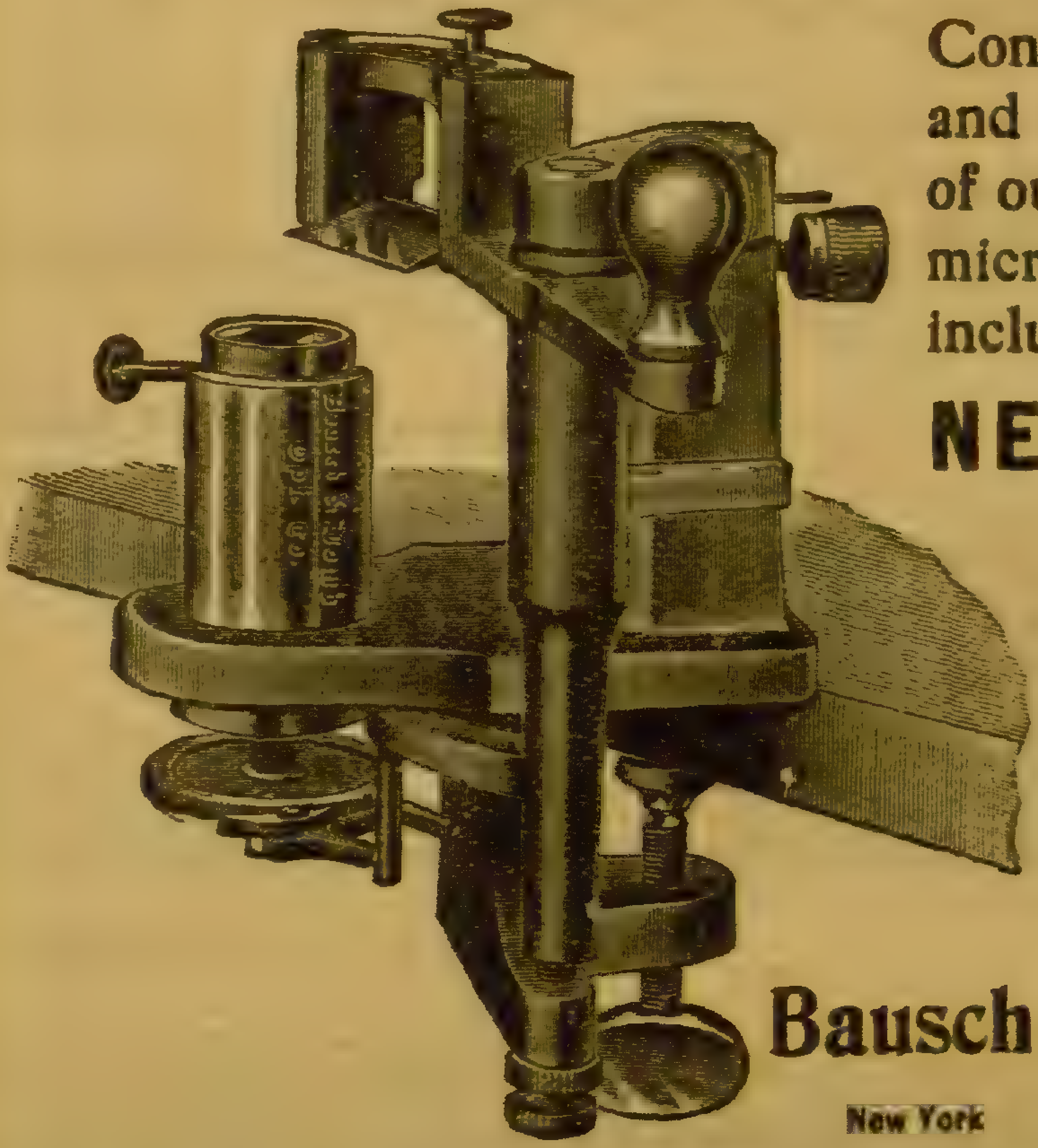

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A NEW AGRICULTURAL ANT FROM TEXAS, WITH REMARKS ON THE KNOWN NORTH-AMERICAN SPECIES.[1]

WILLIAM MORTON WHEELER.

The genus Pogonomyrmex, comprising the true "agricultural ants," is one of several formicid genera peculiar to the American fauna. It comprises more than a dozen species which range from Montana to Argentina, often over wide areas, though apparently absent from considerable portions of this vast region. As the species are mostly large and conspicuous and inhabit exposed situations, they have attracted more attention than many of our American ants. Notwithstanding this fact, however, we are still very far from possessing an adequate knowledge of the habits and taxonomic relationships of the various members of the genus.

The species described in the following pages seems to have escaped attention hitherto on account of its idiosyncrasies. It is small and inconspicuous, of a timid disposition, and lives under stones, instead of in exposed grassy regions like the other North-American species. It is, moreover, rather rare

[1] *Contributions from the Zoölogical Laboratory of the University of Texas*, No. 24.

and local. Up to the present time I have seen it in only one locality, on the flat limestone terraces which form the southern slope of Mt. Barker, a short distance from the Colorado River, near Austin, Texas. Though but a few acres in extent and on warm days fully exposed to the rays of a pitiless sun, these terraces are, nevertheless, a rich collecting ground for the myrmecologist. All about the place there is something of the local color of the dry Mexican plateau, and this peculiarity extends also to the ant-life of the region. Here, under the flat, detached pieces of limestone scattered among a sparse but interesting vegetation,[1] occur at least four species of grain-storing ants: the new Pogonomyrmex described below, a golden yellow variety of the ubiquitous subtropical and tropical "fire ant" (*Solenopsis geminata* Fab.), and two species of Pheidole (a diminutive new form and *Ph. kingii* André, var. *instabilis* Emery). This is also one of the few localities in which I have seen the little mushroom-growing ant *Cyphomyrmex wheeleri* Forel, the first of its genus to be taken in the United States.[2] Here, too, occur *Odontomachus clarus* Roger, *Pheidole hyatti* Emery, *Xiphomyrmex spinosus* Pergande, and, of course, *Dorymyrmex pyramicus* Rog., *Forelius fœtidus* Buckley, and *Camponotus fumidus* Rog., var. *festinatus* Buckley. While many of these species abound in this locality, I have failed to find more than a dozen nests of the new Pogonomyrmex, and these were so close together — within an area of

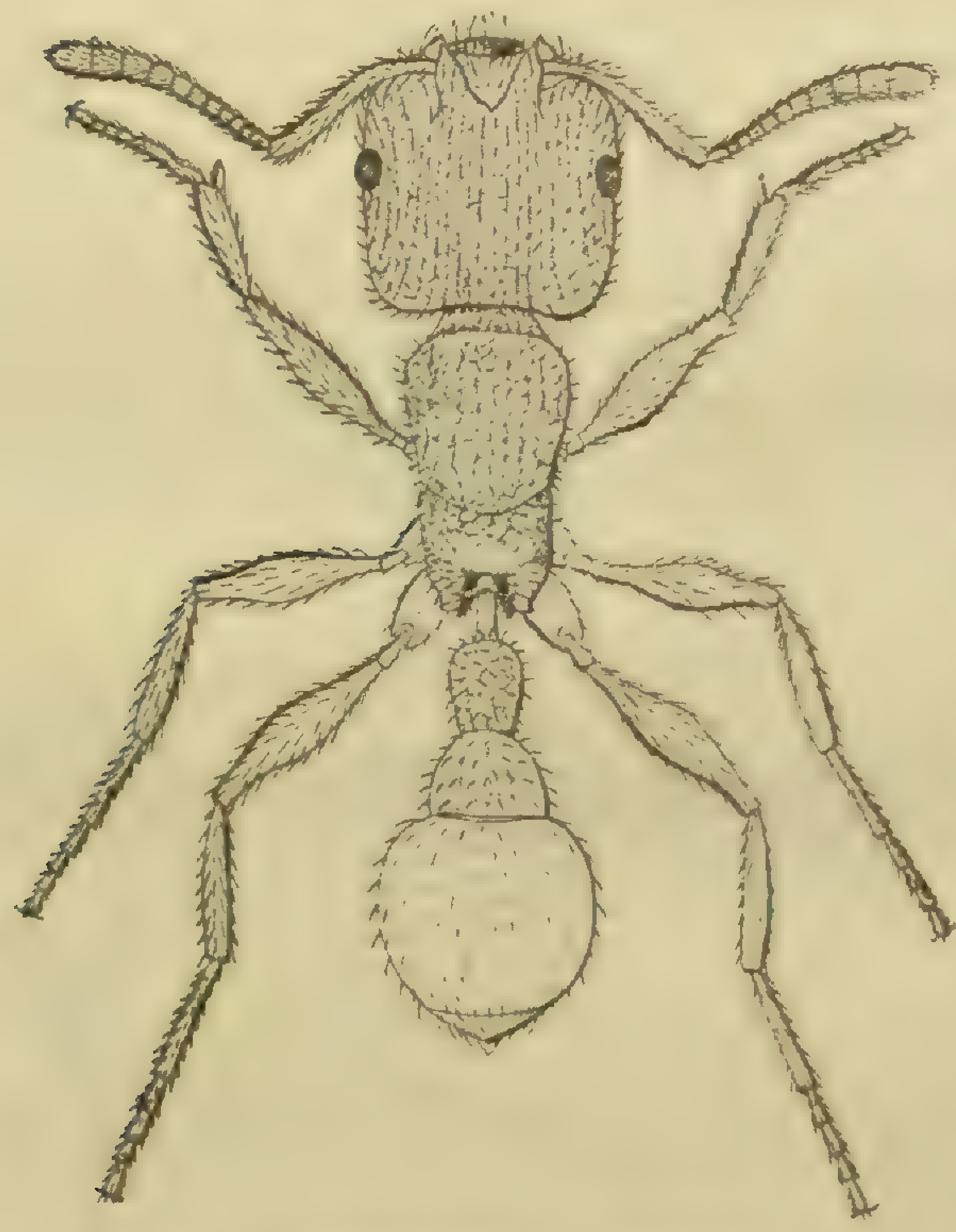

FIG. 1. — *Pogonomyrmex imberbiculus* n. sp. Worker. Dorsal view.

[1] A brief account of the flora of this region is given by Oberwetter ('86).

[2] I have since discovered a dark variety of *C. rimosus* Spinola at New Braunfels, Texas.

a few square rods — as to suggest that they may have been merely parts of a single colony. These nests were all under rather small flat stones, which were often located by following up the foraging workers as they trudged home slowly over the hot soil in the intense glare of the sun. The nest is a simple structure consisting of a few broad and very shallow surface chambers (1½–3 inches in diameter) connected by one or two vertical or oblique galleries with a few chambers situated at lower levels in the soil. The superficial chambers always contained from about ½ to ⅔ of a teaspoonful of seeds, mostly, but not exclusively, from the grasses of the neighborhood. These seeds were all dry and unhusked, and hence of a very different appearance from those found in neighboring nests of *Solenopsis geminata*. This ant carefully shells its seeds and treats them in some singular manner, so that they all have a glistening yellow color like the ants themselves. Although I collected the Pogonomyrmex at different times of the year and excavated their entire nests, it was impossible to discover either the queens or the males. Even the larvæ and pupæ, found in great numbers in the chambers of the nests June 1–10 were all of the worker type. The specific description which follows is drawn therefore exclusively from the worker. This, however, can scarcely be confounded with the workers of any of the other North-American species of the genus.

Pogonomyrmex imberbiculus n. sp.

Worker: Length 4–4.8 mm. Color rich ferruginous red, legs somewhat paler, eyes and edges of mandibles black; hairs covering the body yellowish. Head quadrangular, scarcely longer than broad, its posterior margin hardly incised. Mandibles sexdentate, the two apical teeth largest, blades traversed nearly their entire length by coarse longitudinal ridges. Clypeus subopaque, with longitudinal rugæ separated by series of faint striæ and provided with long, anteriorly projecting hairs. Antennal scape covered with faint longitudinal ridges. the hairs on its anterior surface suberect, on the posterior surface more appressed. Dorsal and lateral surfaces of head covered with coarse rugæ, which are scarcely divergent behind and connected with one another by irregular transverse ridges; the areolæ thus enclosed are subglabrous, coarsely and confluently punctate. Hairs on the upper and lateral surfaces of the head short, erect, subobtuse. Lower surface of head more delicately longitudinally rugose, with somewhat longer

and more tapering hairs, which, however, do not form a conspicuous beard as in the other North-American species of Pogonomyrmex. Thoracic dorsum and pleuræ covered with coarse reticulate rugæ, enclosing more finely reticulate rugose and confluently punctate, polygonal areolæ. In some specimens the rugæ have a transverse trend on the pronotum and a slightly longitudinal trend on the meso- and metanotum; promesonotal suture usually indistinct. Epinotum armed with two pairs of rather blunt spines, scarcely longer than the breadth of their bases; anterior pair connected with each other at the base by a transverse ridge and with the spines of the posterior pair on either side by a longitudinal ridge; the space thus enclosed is subglabrous and traversed by a few longitudinal rugæ. Hairs covering the thorax short, subobtuse, and perfectly erect. Stem of petiole laterally compressed, slender, provided below near its insertion with a small but distinct tooth; node scarcely longer than the stem, its apex obtuse in profile, its dorsal surface subelliptical, covered with coarse reticulate rugæ like those of the thorax, but bearing somewhat longer and more pointed hairs. Postpetiole campanulate, subdepressed dorsally, with a prominent rounded projection below near its base; sculpture decidedly fainter than that of the petiole and consisting of rather indistinct rugæ interspersed with punctate spaces. Gaster small, smooth, and shining throughout, without basal striæ and punctures, and covered with prominent, suberect hairs. Legs glabrous, clothed with suberect hairs.

FIG. 2. — *Pogonomyrmex imberbiculus* n. sp. Worker. Profile view.

While *P. imberbiculus* is very sharply distinguished from any of the other North-American species of Pogonomyrmex by its small size, peculiar sculpture, and the lack of the beard of long hairs which suggested the generic name to Mayr ('**68**, p. 11), it is, singularly enough, very closely related both in these and other particulars to a Brazilian species, *P. nægelii* Forel ('**86** pp. 4, 5). Through the kindness of Professors Forel and Emery, who have sent me specimens of the Brazilian form, I have been able to compare the two species, which at first sight would almost certainly be confounded. More careful examination, however, reveals the following differences: In *nægelii* the gaster is of a distinctly darker color than the head and thorax, and its extreme basal portion is longitudinally striated and finely

punctate. The head, thorax, and petiole are somewhat more coarsely rugose than in *imberbiculus*, and the epinotal spines more acuminate at their tips. The most striking difference, however, is in the sculpture of the postpetiole, which in *nægelii* is but little finer than that of the petiole, whereas in the Texan species this segment is nearly smooth.

Recently Forel ('99, pp. 61, 62) has discovered in Columbia still another beardless and otherwise aberrant Pogonomyrmex (*P. mayri*), which he assigns to a new subgenus, Janetia. This is based very largely on the predaceous, non-granivorous habits of the species and on the neuration of the male fore wings, which exhibit only a single cubital cell. He expresses doubt as to whether *P. nægelii* should be included in his new subgenus, but leaves the matter undecided, as he supposes the male of this species to be unknown. This, however, appears to be an oversight, since Mayr ('87, p. 612) describes both the male and female of *P. nægelii*. He clearly states that the female has two cubital cells and that the wings of the male are the same as those of the female. Now from the very close affinity of *P. imberbiculus* with *P. nægelii* it is safe to predict that the latter is also a grain-eating species. We are compelled, therefore, to regard the small group of Pogonomyrmex comprising the beardless Texan and Brazilian species as transitional between Pogonomyrmex *sensu stricto* and the subgenus Janetia rather than as belonging to the latter. It may be advisable ultimately to erect a special subgenus for the two small grain-storing species, but a careful study of the males and females of all the known species of the genus should be previously undertaken.

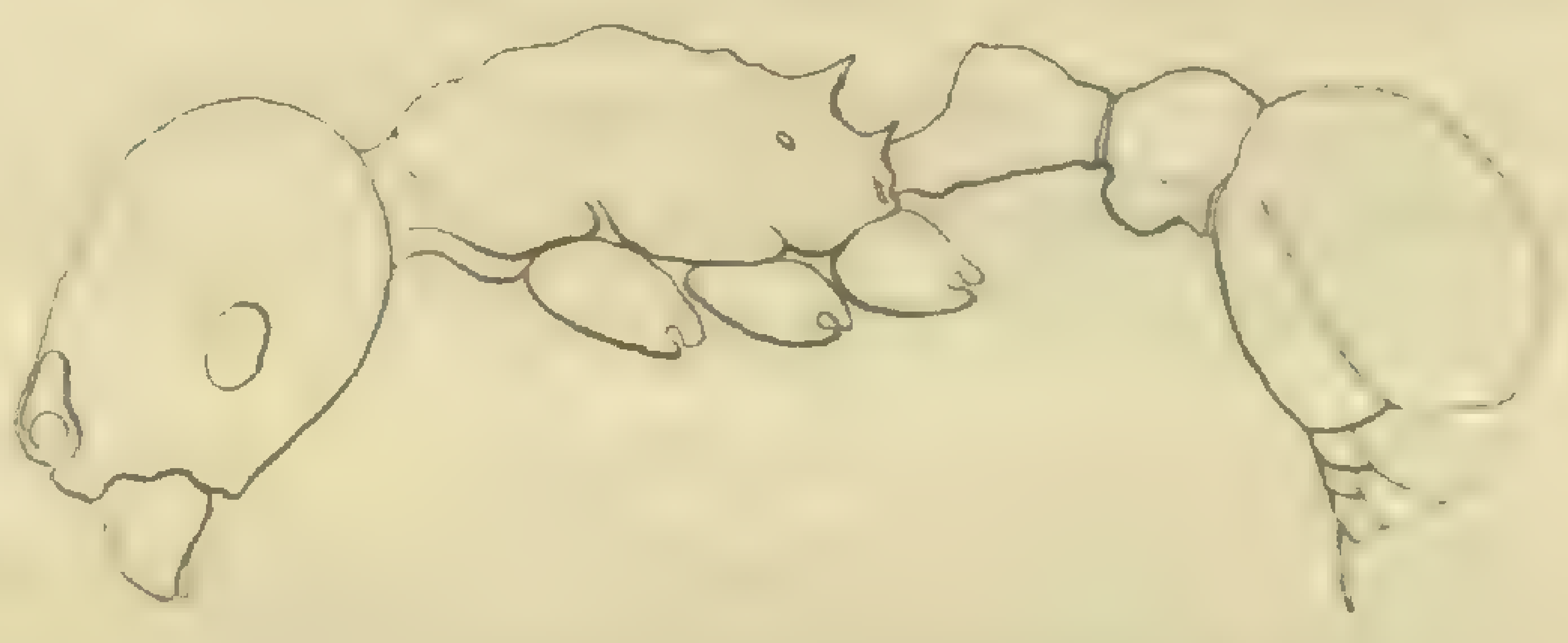
FIG. 3. — *Pogonomyrmex nægelii* Forel. Worker.

The workers from two nests of *P. imberbiculus*, with their numerous pupæ, nearly mature larvæ, and their store of seeds, were put together in the same artificial nest. The ants from different nests fraternized without the slightest signs of hostility,

thereby indicating that they were perhaps members of the same colony. They soon distributed their progeny and provisions in three separate piles — one for the larvæ, one for the pupæ, and one for the seeds. During the first few days of their captivity the ants were fed on house flies. These were not only eaten with avidity by the adult Pogonomyrmex, but cut into pieces and fed to the larvæ in the same manner as I have described for the Ponerinæ and some Myrmicinæ ('00 and '00a). On one occasion nearly every larva in the nest could be seen munching a small piece of house fly. But a still more remarkable method of feeding was adopted after a few days, when the supply of insect food was exhausted. Then the ants were seen to bring seeds from their granary, crack them open with their strong mandibles, and, after consuming some of the softer portions themselves, to distribute the remainder among their larvæ. The latter could be seen under the lens cutting away with their mandibles and devouring the softer starchy portions of the seeds. The hard and useless hulls were afterwards carried away by the ants and placed on the refuse heap. These observations show that *the larvæ of certain ants are not only able to subsist on solid food, but even on food of a vegetable nature.* The adaptation of what were probably once exclusively carnivorous ants to a vegetable diet, although not yet complete, is, nevertheless, so far advanced that the larva already participates in the peculiar feeding habits of the adult insect. The *P. imberbiculus* seem not to possess the power of feeding one another or their larvæ by regurgitation. At any rate they were not seen to make use of this method in the artificial nests.

These observations are quite in line with some which I made on artificial nests of the large "agricultural ant of Texas" (*P. barbatus* Smith, var. *molifaciens* Buckley). In this case the workers carried the seeds, a few at a time, into the chamber containing the queen and her attendants. Here the ants, including the queen, gnawed away the soft portions of the seeds till they had satisfied their hunger. Thereupon the empty hulls were carried out. Even when the nest was supplied with honey or syrup, each ant helped herself from the food supply, and neither fed other ants nor permitted herself

to be fed by regurgitation. I deem it probable, therefore, that the larvæ of *molifaciens* are also fed like those of *imberbiculus* by what we may call the direct method, to distinguish it from the indirect method adopted by the Camponotinæ. In the Ponerinæ and many Myrmicinæ, including Pogonomyrmex, the direct appears to be the prevailing, if not the exclusive, method. In the Camponotinæ, on the other hand, the indirect method prevails, since at a given time only a comparatively small number of ants function as caterers for the whole colony and distribute the food by regurgitation to the larvæ and the other ants.

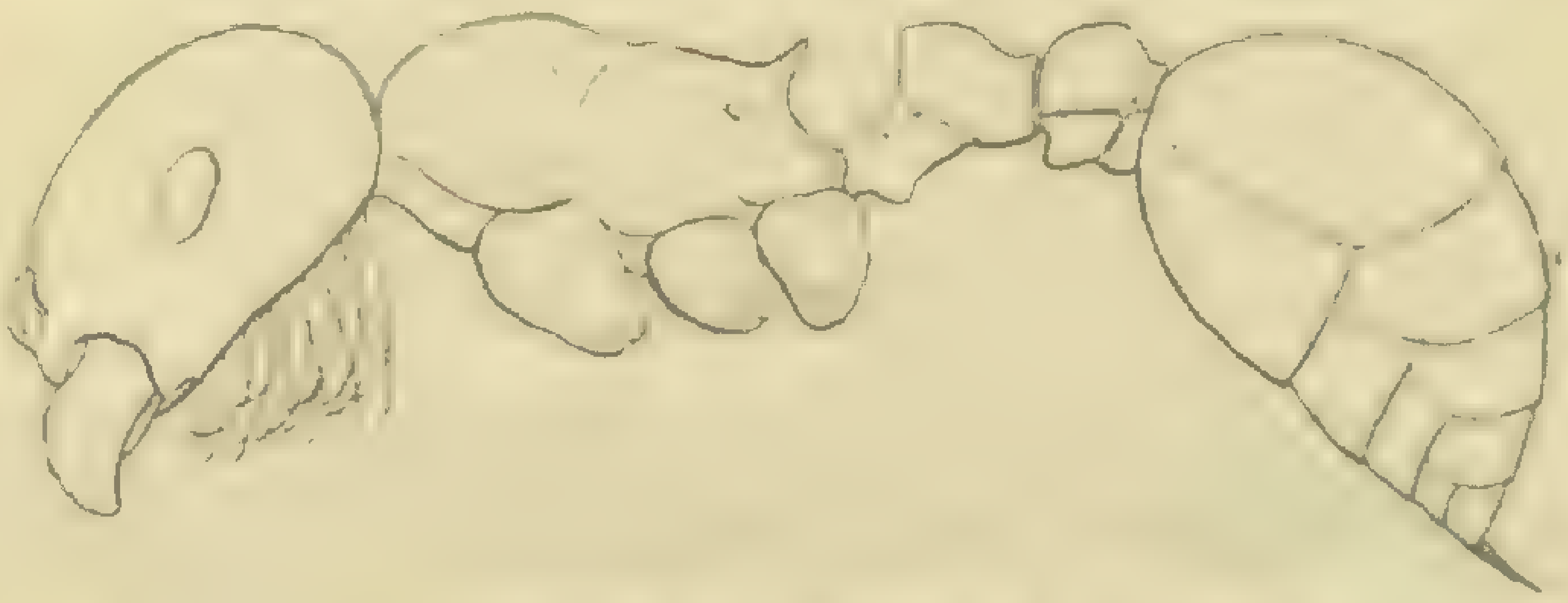

Fig. 4. — *Pogonomyrmex barbatus* F. Smith (typical). Worker.

It may not be altogether out of place in this paper to record a few other observations on *P. molifaciens*, inasmuch as this form has been singled out among all the known members of the genus as presenting certain remarkable instincts. Lincecum is responsible for the myth that this Pogonomyrmex sows a certain species of grass, the "ant rice" (*Aristida oligantha*), protects it from harm and frees it from weeds while it is growing, for the purpose of reaping the grain. This notion, which even the Texan schoolboy has come to regard as a joke, has been widely cited, largely because the great Darwin stood sponsor for its publication in the *Journal of the Linnean Society* (**'62**). McCook, after spending a few weeks in Texas observing *P. molifaciens* and recording his observations in a book of 310 pages (**'79**), failed to obtain any evidence either for or against the Lincecum myth. He merely succeeded in extending its vogue by admitting its plausibility.[1]

[1] Not only have able myrmecologists like Forel (**'99**, p. 63) been deceived by the accounts of Lincecum and McCook into assuming the existence of a kind of symbiotic relation between the Pogonomyrmex and the "ant rice," but this myth, now in its fortieth year, still flourishes in the newspapers. There it grows by intussusception with other droll fancies, as shown in the following extract from the *Chicago Tribune* of May 19, 1901: "Many species of ants fertilize and apparently cultivate many varieties of foodstuffs. The trimmer ants and the

Two years of nearly continuous observation of *P. molifaciens* and its nests enable me to suggest the probable source of Lincecum's and McCook's misconceptions. In either case the observer has started with a few facts and has then stopped short to draw inferences before gathering more facts. If the nests of *molifaciens* be studied during the cool winter months, — and this is the only time to study the nests leisurely and comfortably, since the cold subdues the fiery stings of their inhabitants, — the seeds which the ants have garnered in many of their chambers will often be found to have sprouted.[1] On sunny days the ants may often be seen removing these seeds when they have sprouted too far to be fit for food and carrying them to the refuse heap, which is always at the periphery of the cleared earthen disk or mound. In this place the seeds thus cast away as inedible often take root and somewhat later form an arc of tall grass more or less closely approximating a complete circle around the nest. Since the Pogonomyrmex feeds largely, though by no means exclusively, on grass seeds, and since, moreover, the seeds of the Aristida are a very common and favorite article of food, it is easy to see how this grass should often predominate in the circle. In reality, however,

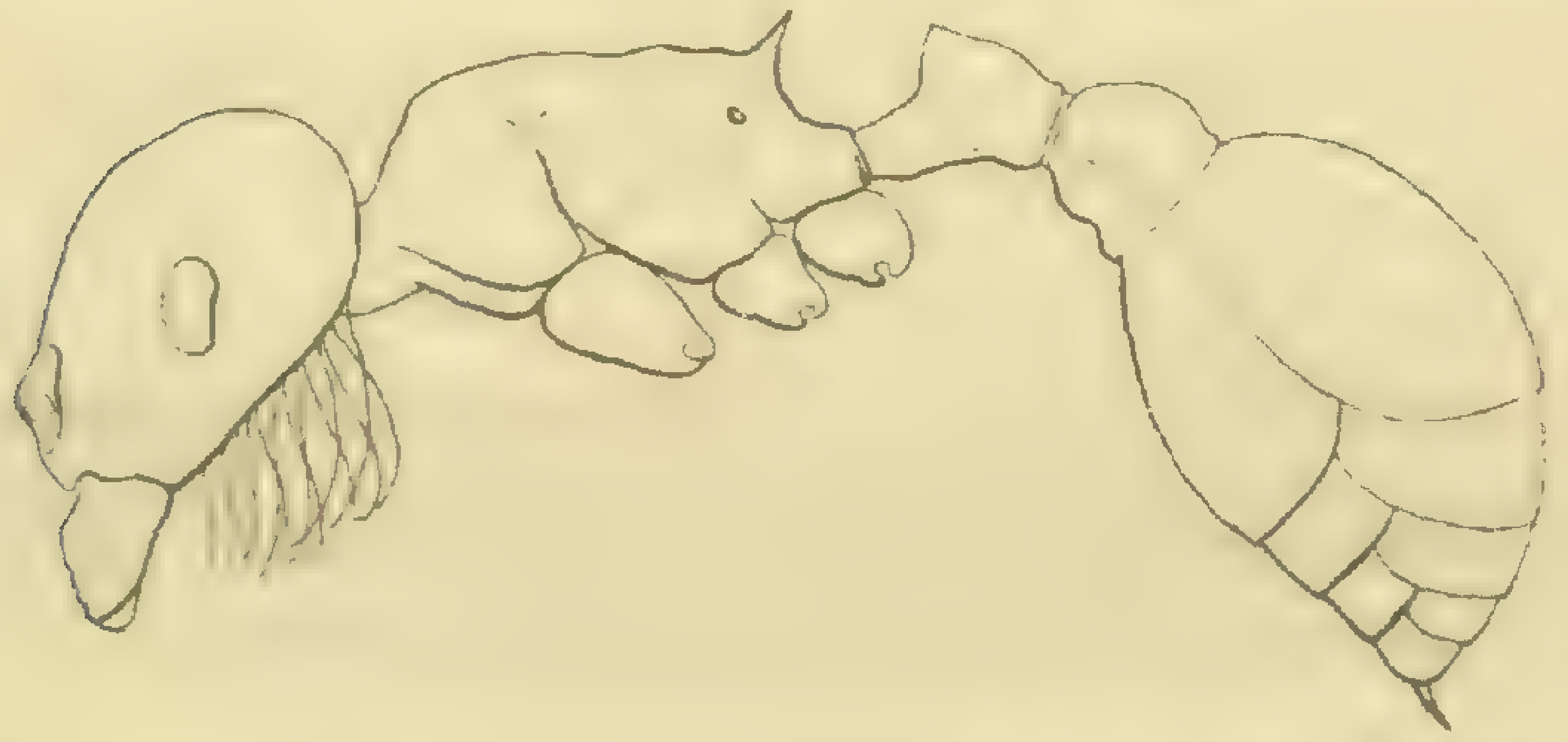

FIG. 5. — *Pogonomyrmex occidentalis* E. T. Cresson. Worker.

harvesting ants of Texas are both of this kind. The trimmers prune a sort of weed which is to their taste so that it shall grow strong and sturdy, and the harvesting ants go even further than this. They clear disks several yards across around about their nests of all manner of vegetation. Then they plant these farms with ant rice, which they watch and tend until it ripens, keeping the crop carefully free of weeds and insects. The ants' dogs keep the ant cows out of the growing grain, and the farmer ants probably sit around themselves at night with shotguns to shoot colored ants suspected of pilfering."

[1] The same is true of the seed stores of *Pheidole kingii*, var. *instabilis*. It is therefore certain that these ants are not able to prevent the seeds from germinating as Moggridge ('73, p. 54) claims for the European species of Messor, except by conveying them to drier chambers. And in protracted spells of wet weather even this precaution seems to be of no avail.

only a small percentage of the Pogonomyrmex nests, and only those situated in certain localities, present such circles. Now to state that the *molifaciens*, like a provident farmer, sows this cereal and guards and weeds it for the sake of garnering its grain is as absurd as to say that the family cook is planting and maintaining an orchard when some of the peach stones which she has carelessly thrown into the back yard with the other kitchen refuse chance to grow into peach trees.[1]

There are several other facts which show that the special ring of grass about the *molifaciens* nest is an unintentional and inconstant by-product of the activities of the ant colony. First, the Aristida often grows in flourishing patches far from the nests of *molifaciens*. Second, one often finds very flourishing ant colonies that have existed for years in the midst of much-traveled roads or in stone sidewalks often a hundred or more feet from any vegetation whatsoever. In these cases the ants simply resort for their supply of seeds to the nearest field or lawn, or pilfer the oat bin of the nearest stable. Third, it is very evident that even a complete circle of grass like those described by Lincecum and McCook would be entirely inadequate to supply more than a very small fraction of the grain necessary for the support of a flourishing colony of these ants. Hence, they are always obliged to make long trips into the surrounding vegetation, and thereby wear out regular paths which radiate in different directions, often to a distance of forty to sixty feet from the entrance of the nest. These paths in the case of the Mexican agricultural ant (*P. barbatus* sens. str.) remind one of human footpaths, as they may be as much as four to six inches wide in places. The existence of these paths, which are often found in connection with grass-encircled nests, is alone sufficient to disprove Lincecum's statements.

McCook's conceptions of the external architecture of the *molifaciens* nest are hopelessly confused, notwithstanding the

[1] Lincecum was fond of attributing agricultural and horticultural propensities to ants. Thus he states ('**67**, pp. 28, 29) that the leaf-cutting ant (*Atta fervens*) plants trees and vines on its nest! At the same time of course, like McCook, he failed to observe the marvelous mushroom-gardening habits of these ants, — another instance in which truth is stranger than fiction.

fact that he seems to have been much interested in ant architecture, and has devoted no less than thirty-five pages to a presentation of this feature. It does not seem to have occurred to him that the character of the architecture of *molifaciens* must be profoundly affected by two factors, — the nature of the soil and the age of the ant colony. Gravel-cone nests can, of course, be built only in soil that abounds in small pebbles, whereas nests dug in a uniform soft, loamy soil, like that of northern Texas along the Red River, must be simple disks or very low mound nests, as the soil brought up by the ants is spread out by the rains and the movements of the ants themselves. On the other hand, a small, incipient colony of ants is unable to clear away much of the vegetation about the entrance to the nest. At least the tougher plants, like the grasses, whose hard siliceous stems offer considerable resistance to the mandibles of the ants, cannot be cut away till the colony waxes strong both in the size and number of its individuals. Then the work proceeds rapidly, the circular area coëxtensive with the subterranean galleries is completely cleared and opened up to the sun's light and warmth. This clearing is evidently an adaptation for insuring the greatest possible dryness in the granaries of the nest. The circular denuded disk or mound enlarges slowly year after year, and it should be noted that during this progressive enlargement even the peripheral circle of ant rice is quite as ruthlessly cut down and cleared away along its inner edge as any other plants that may cast a shadow on the disk, and thereby enable the soil to retain the moisture.

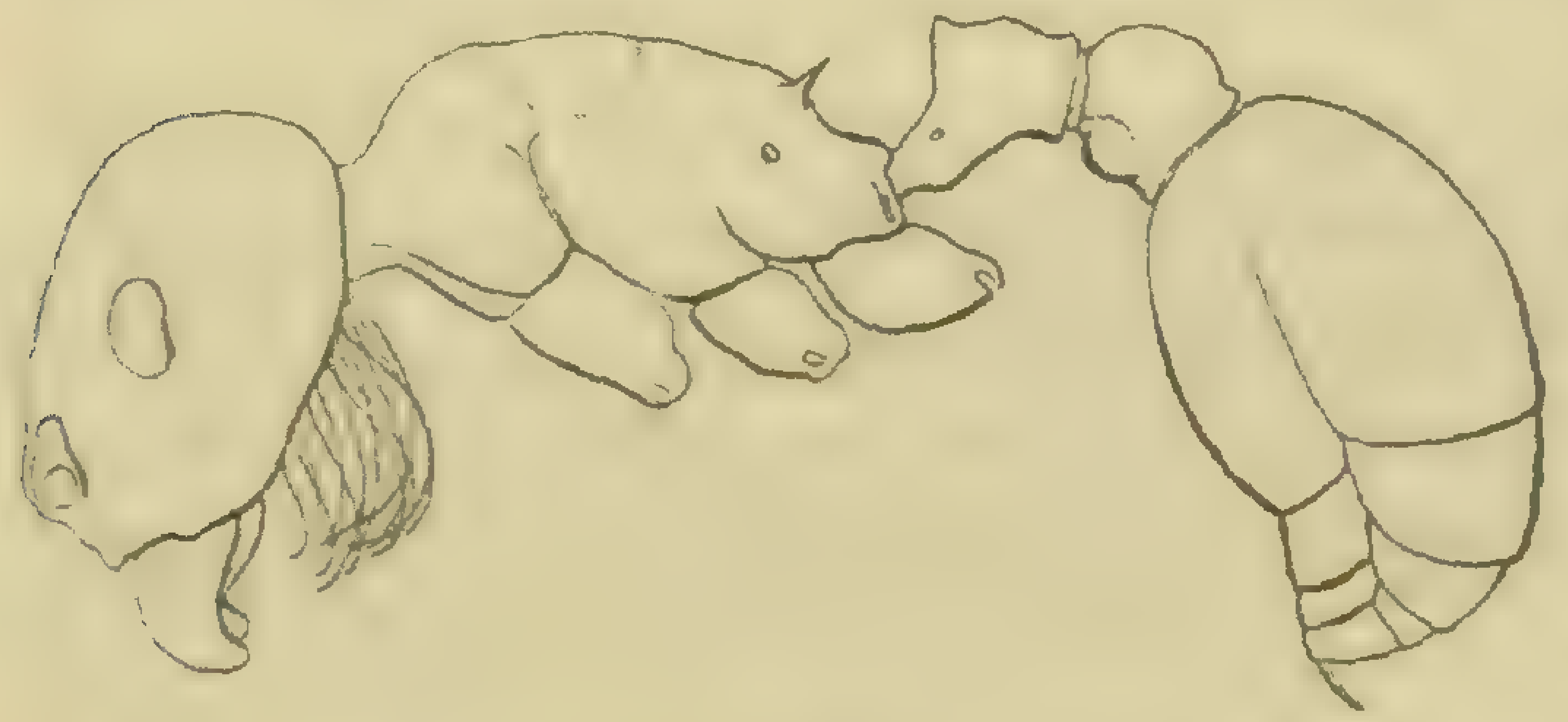

Fig. 6. — *Pogonomyrmex subdentatus* Mayr. Worker.

While we possess the observations of Buckley ('**61**), Lincecum ('**62**, '**66**, '**74**), and McCook ('**79**), on the habits of the Texan *P. molifaciens*, of Mrs. Mary Treat ('**77**) and McCook ('**79**) on the "Florida harvester" (*P. badius* Latr.), and of McCook ('**82**)

on the "occident ant" (*P. occidentalis* Cresson), no observations seem to have been published on the two distinctively Californian species (*P. californicus* Buckley and *P. subdentatus* Mayr). My friend Dr. Harold Heath, who has made strenuous effort to fill this gap in our knowledge, kindly supplies me with the following notes on the latter species:

The red agricultural ant (*P. subdentatus*) is one of the most abundant ants in the neighborhood of Pacific Grove, Cal. Here one is constantly coming upon them and their nests along the roadsides and in the sandy soil of the woods and fields. The nests, so far as I have been able to observe, are never placed under stones or logs, but in exposed regions, — that is, away from the shadow of vegetation. Little attempt is made to clear away the short grass in their vicinity. The earth carried out from their burrows is usually deposited several inches from the opening, especially along their runways, which extend out in various directions into the surrounding region. Large quantities of chaff and the hulls of seeds are also scattered about, usually in fairly definite dumping grounds, but neither these materials nor the earth are ever fashioned into a mound. Some of the ants entering the nest carry pods, others bits of leaves and grass, all well dried, while an equal number of the insects leaving the nest carry away similar materials, but the pods are emptied of their seeds and the leaves are evidently thrown away as non-nutritious and useless. Within the nest there are several little granaries, or accumulations of seeds, each sometimes amounting to as much as a teaspoonful, though usually considerably less. The foodstuffs seem to be carried to one spot within the nest and there hulled and assorted. The seeds are then carried to the storehouses, while the chaff is at once carried out, although it may accumulate and almost completely fill a burrow for a distance of several inches. On comparing the seeds taken from the nest with those of the surrounding plants, I find them to be chiefly those of a species of grass and of two species of Compositæ. At the present writing these seeds are fully ripe, but as soon as those of other plants mature they appear to be equally acceptable. I may add that these ants defend their homes with extraordinary pugnacity and inflict stings more painful than those of the honey-bee. As I write I feel the dull ache of several stings inflicted more than a day ago.

These observations, by a thoroughly competent zoölogist, show that at least one of the Californian species of Pogonomyrmex conforms rather closely to what is known of the other species of the genus.

Some interesting problems center about the geographical distribution of the species of Pogonomyrmex. These ants

evidently represent an extreme adaptation to the open, dry and sunny, and more or less grass-covered regions of the New World. Such regions are, perhaps, most typically represented by the deserts of Wyoming, the plateau of central and northern Mexico, and the pampas of La Plata. The area occupied by the genus and extending, as above stated, from Montana to Argentina, presents in North America an eastern offshoot to Florida (*P. badius*) and a peculiar western offshoot to the Sandwich Islands (*P. occidentalis*). In South America there is between Colombia and Argentina a considerable area from which species of Pogonomyrmex are unknown, but the continuity of the distribution, though broken at this point, is at least in part preserved further to the east by the Brazilian *P. nægelii*.

Fig. 7. — *Pogonomyrmex californicus* Buckley. Worker.

This distribution over two continents naturally suggests an inquiry as to whether the species arose in North America and migrated thence along the Andes into South America, or had their origin in the pampas of Argentina and migrated into North America over the same lofty road. Two authors, v. Ihering (**'94**, p. 416) and Emery (**'94**, p. 354), who have seriously studied the interesting problems suggested by the distribution of the American ants, agree in regarding North America as the primeval home of the species of Pogonomyrmex. Concerning this genus and the genera Dorymyrmex and Forelius, which have a very similar distribution, Emery says:

Their migration probably proceeded along the Andes at a time when the climate was cooler and the vegetation therefore different from the present. Later, on the supervention of new floral conditions, they were crowded out of a portion of their former domain by the tropical ant fauna. For the reason that the southern species of Pogonomyrmex and Dorymyrmex are more numerous than the northern, we might, perhaps, assume that these animals had migrated from the south to the north. But it is not in

the least improbable that these ants, like the South-American species of Didelphys, deer, camelids, and mastodons, are of North-American origin. Without being able to adduce stringent proof in favor of my opinion, I nevertheless incline to accept this latter view.

The migration between the continents is supposed to have taken place during the Pliocene. This view of the North-American origin of Pogonomyrmex is supported to some extent by the flourishing condition of the closely allied holarctic genera Myrmica and Stenamma (including the subgenera Aphænogaster and Messor) in the United States and Canada.

A problem of more subordinate interest is suggested by the close morphological relationship of the Brazilian *P. nægelii* and the Texan *P. imberbiculus*, without known forms of a similar aberrant character in the intervening geographical region. It is possible, however, that a more searching investigation of the Mexican and West-Indian fauna may bring to light still other beardless forms of Pogonomyrmex and thereby fill this gap. It should be mentioned, nevertheless, that the new Texan species has all the appearance of being a geological "relict."

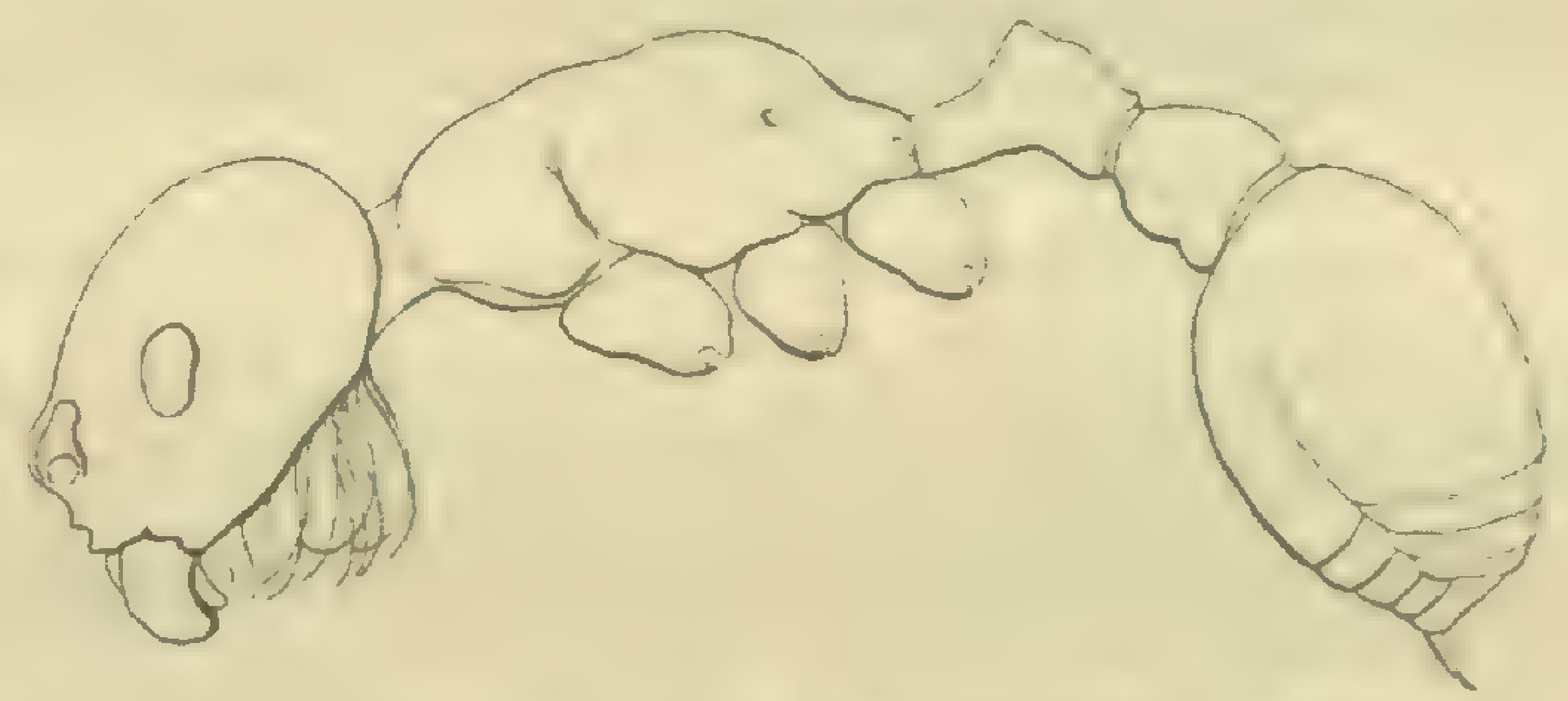

FIG. 8. — *Pogonomyrmex badius* Latreille. Worker.

In conclusion I subjoin a dichotomic table to aid in the identification of the workers of the North-American species of Pogonomyrmex:

1. Small species, less than 5 mm. long: under surface of head without a beard of long curved hairs: epinotum armed with four spines: head, thorax, and petiole coarsely reticulate rugose, base of gaster not striated. Formicary under stones. (Central Texas.) *P. imberbiculus* n. sp.

2. Larger species, more than 5 mm. long: under surface of head with a beard of long, curved hairs; epinotum with only two spines or none: head and thorax finely rugose, the rugæ being more or less parallel with one another, not reticulate. Formicary not under stones, exposed 3

3. Epinotum with a single pair of spines 5

4. Epinotum unarmed 12
5. Head finely and densely rugose, rugæ but little divergent posteriorly, without or with very indistinct interrugal sculpture . . . . 7 *a–e*
6. Head less densely rugose, rugæ very distinctly divergent posteriorly, interrugal sculpture distinct, consisting of dense foveolate punctures 8
7 *a*. Head, thorax, and legs black; petiole, postpetiole, and gaster red. (Mexico.) . . . . *P. barbatus* F. Smith (**'58**, p. 130)
7 *b*. Cephalic rugæ finer and denser, body ferruginous red throughout. (Mex., Tex., Ind. Ter., Ark., Kans.)
P. barbatus, var. *molifaciens* Buckley (**'61**, p. 445)
7 *c*. Head and thorax brownish red, gaster in part or entirely brown. Rugosity as in 7 *b* or somewhat stronger. (Tex., Col.)
P. barbatus, var. *fuscatus* Emery (**'94**, p. 309)
7 *d*. Rugosity a little coarser than in 7 *a*; head, thorax, and legs black, petiole and postpetiole brown, abdomen red, node of petiole longitudinally rugose. (Marfa, Tex.) . *P. barbatus*, var. *marfensis* n. var.
7 *e*. Head and thorax much more coarsely rugose than in 7 *a–d*. Rugæ irregular in direction on the pro- and mesonotum, on the other regions transverse. Petiole rather strongly and irregularly rugose; its anterior stem-like portion shorter than in *P. barbatus*; postpetiole rugose-punctate. (Cal.) . *P. barbatus*, subsp. *rugosus* Emery (**'94**, p. 309)
8. Head less densely rugose, the rugæ distinctly divergent posteriorly, interrugal spaces densely foveolate punctate 9
9. Lower surface of petiole without a distinct tooth; infraspinal concavity of epinotum rugose, scarcely shining . . . . 10 *a–b*
10 *a*. Head opaque, interrugal punctures distinct. (Col., New Mex., Utah, Ariz., Nev., Wyo., Mont., Kans., Neb., Honolulu.)
P. occidentalis Cresson (**'65**, pp. 426, 427)
10 *b*. Head more shining, interrugal punctures more indistinct; petiole less opaque than in 10 *a*. (S. Cal.)
P. occidentalis, var. *subnitidus* Emery (**'94**, p. 310)
11. Petiole with a distinct tooth below; infraspinal concavity of epinotum shining, without rugæ. (Cal.) . *P. subdentatus* Mayr. (**'70**, p. 971)
12. Interrugal spaces of head rather indistinctly and confluently punctate. Workers monomorphic . . . . 13 *a–c*
13 *a*. Color yellowish red, stem of petiole about the same length as its nodal portion; postpetiole as high as long. (Cal., Lower Cal.)
P. californicus Buckley (**'66**, p. 236)
13 *b*. Darker red than 13 *a*; apical third or more of gaster more or less black; petiole and postpetiole often brown, the former slender, its node longer and less erect, with rounder or but slightly pointed apex. (Lower Cal.)
P. californicus, var. *estebanius* Pergande (**'93**, p. 33)
13 *c*. Yellowish red, gaster brown except at the base: stem of petiole shorter than the very long nodal portion, which is pointed above;

postpetiole not as high as long. Sculpture fainter than in 13 *a*: petiole and postpetiole punctate, without rugæ. (Cal.)

P. californicus, subsp. *longinodis* Emery (**'94**, p. 311)

14. Interrugal spaces regularly foveolate punctate. Color ferruginous red. Workers polymorphic, *i.e.*, with size of head greatly varying. (N. C., Ga., Fla.) . . . . . *P. badius* Latreille (**'02**, p. 238)

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COLEBROOK, CONN., September 9, 1901.

PHYLLOSPADIX AS A BEACH-BUILDER.[1]

RALPH ERWIN GIBBS.

In December, 1898, while overhauling a heap of seaweeds recently collected by Prof. W. A. Setchell and myself at Bodega Bay, California, I discovered, clinging to a branch of Amphiroa, a small brown object which bore, at first sight, a rude resemblance to a beetle's head with rigid, bristle-fringed antennæ. On examination, however, it was evident that this nondescript, clasping the Amphiroa in such a way that the reflexed bristles, or "barbs," of its arms resisted attempts to detach it, was the seed or fruit of some flowering plant. Further, it was obvious that this contrivance of arms and bristles was a unique and most interesting example of dissemination mechanism.

As there are extensive beds of eelgrass (Phyllospadix) growing in shallow water along the rocky shores of Bodega Bay, the possibility suggested itself that this was the ripe fruit of Phyllospadix, and upon comparison with the figures of Ruprecht and others it seemed that such was the case, — although our find was, in some respects, very different from what Ruprecht supposed to be the "ripe fruit."[2]

A few weeks later, at Monterey Bay, the matter was put beyond doubt, and given new complexity and interest, when we collected not only an abundance of the fruits, but also young plants in several stages of development. Following up these discoveries, and with the help of Professor Setchell and Dr. W. L. Jepson, I made an investigation, the results of which are here set forth. These results, to anticipate a summary, are, first, some data as to the life history of Phyllospadix, and, second, some speculation as to the significance of the plant from a geological point of view.

[1] Thesis for the degree of M.S., University of California, May, 1900.

[2] Ruprecht, F. J. Neue . . . Pflanzen aus dem . . . Stillen Oceans. 1852.

First we consider the fruit itself. Upon comparison of Figs. 2 and 3 it is seen that our wave-beaten specimen from Bodega, with its long stiff arms, lined with brushes of inflexed bristles, is a decided departure from Fig. 2, which represents the most mature fruit I have been able to find still attached to the spadix. Fig. 2 is also an approximate reproduction of Ruprecht's figure. Fig. 1 shows a younger stage.

FIG. 1.

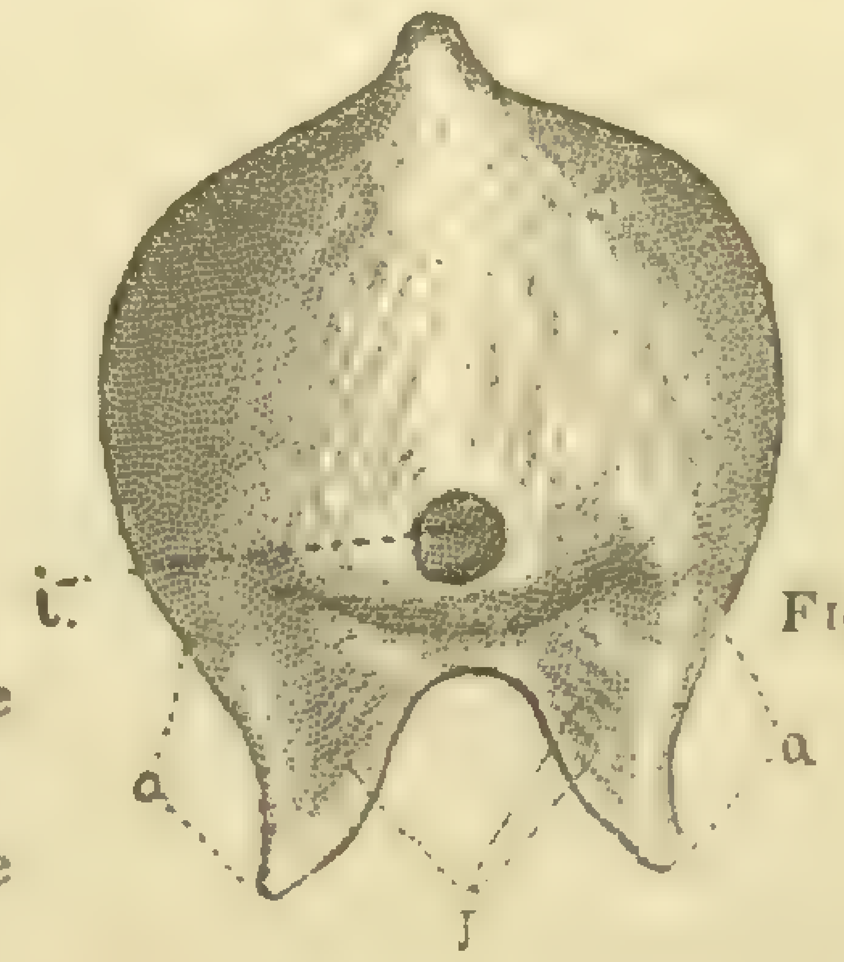

FIG. 2.

FIG. 1.—Early stage of fruit.

FIG. 2.—Later stage of same.

The feature which catches the attention in Fig. 3 is, of course, the arrangements of the two arms, with the bristles or barbs. This is what I have called the "dissemination mechanism"; but that is rather a misnomer, for it is a device, not for scattering the seeds, but for anchoring them after they have been drifted away from the parent plant.

But the first question is, What is the origin of these barbs, and how are they developed from the object we see in Fig. 2? Curiously enough, the key to this puzzle was unwittingly stumbled upon by Ruprecht in 1852. He noticed upon the fin-like expansion which extends between the body and the arms of the green fruit the parallel darker streaks marked *f* in Fig. 2; for he remarks that, upon dissection, he found imbedded in the softer, semitranslucent tissue, bundles of *braune Fasern*, and it is these brown fibers which, as we shall see, play an important part in one chapter of Phyllospadix life history.

FIG. 3.— Fruit as found attached to Amphiroa.

In Fig. 4 is shown a diagrammatic section of the stage of fruit shown in Fig. 2, cut in the plane of the two arms. The pericarp is here so differentiated that we may distinguish, for convenience, two parts, — what we may call the exocarp, the soft, spongy outer portion; and the endocarp. The latter is thin or absent at the lower end of the seed, but it clasps

the body of it as in a sling of tough, compact tissue, composed of elongated lignified cells. Further, this endocarp, prolonged downward, forms the axes of the arms; and, finally, it produces a great number of very long and thick-walled cells, which lie loosely imbedded in the softer substance of the "fin" (*f*). These "fibers" may be easily separated from one another, and from the enclosing exocarp, except at their lower ends, where they are conjoined with the endocarp of the arms. These slender lignified cells are the *Fasern* of Ruprecht, and now it is to be inquired how they are metamorphosed into the barbs of Fig. 3.

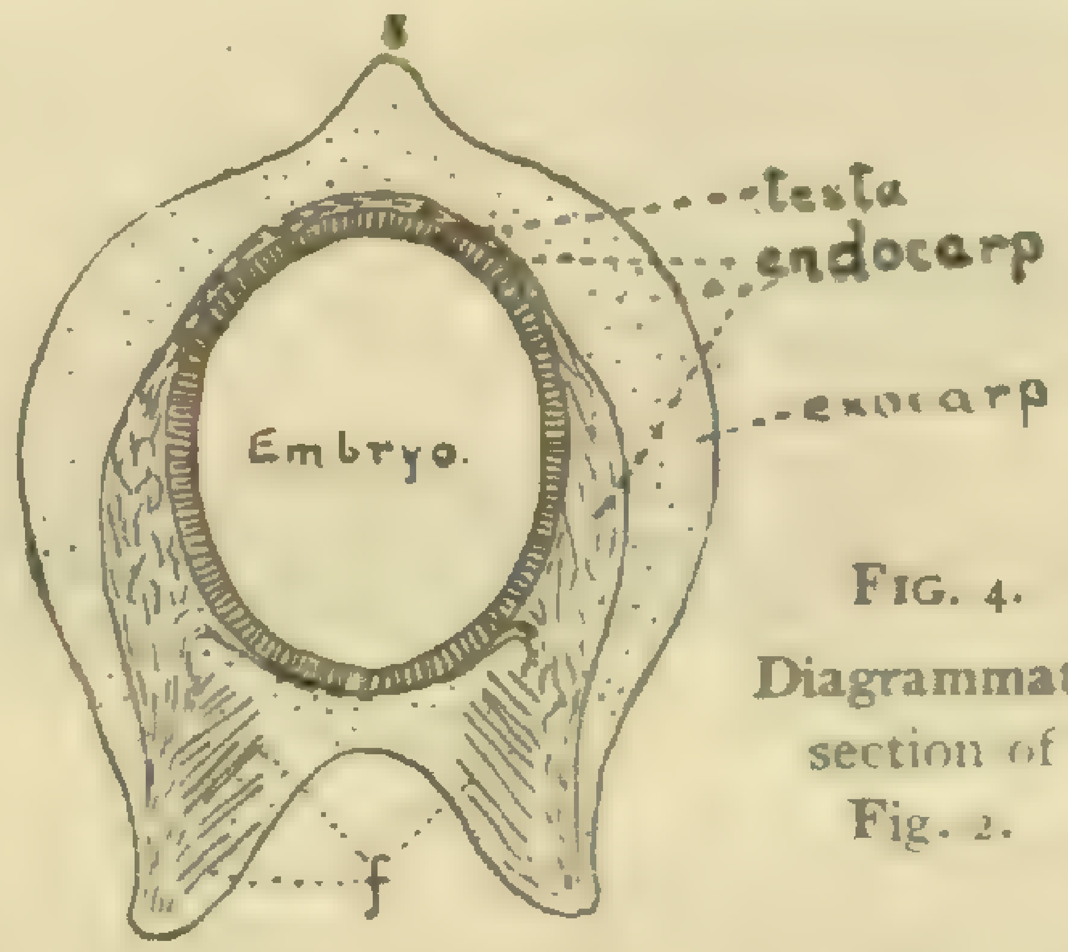

FIG. 4. Diagrammatic section of Fig. 2.

When the ripe fruit is ready to break loose from the spadix, its arms have grown longer and stiffer, as in Fig. 3, but are still, of course, enclosed in the exocarp. Now the fruit begins to drift about, — flung against the rocks, washed up on the beach, and sucked back again, bruised and scoured, in the swirling sand and pebbles of the undertow; and after a little of this rough-and-tumble existence the spongy exocarp begins to wear away, leaving exposed, in the arms and about the upper part of the seed, the hard endocarp, while about the base (*i.e.*, the lower middle part of Fig. 3) there is laid bare the smooth surface of the shell-like testa. But the important point is that the exocarp in which the barbs are imbedded is also got rid of. It easily flakes off and is washed away, and then, with a little more sand-scouring, the freed barbs, springing apart a little, stand out clean, like so many whalebones.

Now our "anchoring mechanism" is uncovered and ready for use. By this time, too, the seed may be ready to germinate, and, for the safe putting forth of leaves, a fixed abiding place is necessary. The seed must be anchored, and, the anchors being ready, the next requisite is a suitable anchoring ground.

Along our coast there are various species of coralline seaweeds (Corallina, Amphiroa) which abound wherever there are rocks between tide-lines. These algæ have slender,

lime-impregnated stems, made flexible by being broken into short joints, and constricted between the joints like a string of coral beads; and they form an intricate, often turf-like, growth over the wave-washed rock.

We could not imagine a better opportunity for Phyllospadix in search of a lodging place; and it seems that Phyllospadix is, in fact, not slow to catch on, for experience showed that the more profitable way to collect Phyllospadix seed was to search at low tide, not in the eelgrass itself, but rather among the corallines covering some flat rock just inshore from the eelgrass beds.

When the fruit, hurried landward by a wave, blunders against a tip of Amphiroa, there is a fair chance that the stem will slip into the crotch of one of the arms. When once this has happened the wanderings of Phyllospadix are over. The many barbs unite to hold whatever is caught, and further knocking about by the waves only serves to wedge the alga more tightly into the grasp of the seed. The segmented structure of the Amphiroa prevents it from slipping through the grip of the arm, and so the seed is safely planted, as it were, in a tree-top. Frequently it even catches two branches of its host, one in either armpit, and so swings secure on two anchors.

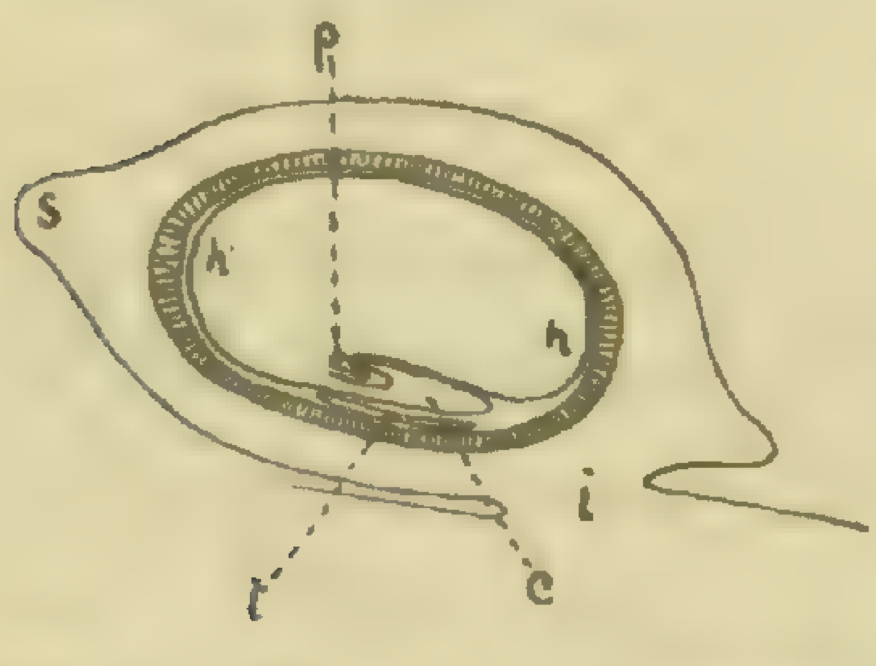

FIG. 5. — Diagram of dorsiventral median section of Fig. 2. *c*, cotyledon; *i*. insertion of pistil; *h*, *h'*. hypocotyl; *l*, folded edge of hypocotyl.

Time and seed are now ripe for germination. What next takes place will be better understood upon referring to Fig. 5. Here is a longitudinal, dorsiventral, median section of the immature fruit. The cavity of the seed is filled by the embryo, of which the bulk consists in the hypocotyl (*h*, *h'*). The cotyledon (*c*) is short, straight, and tubular, and serves merely as a sheath for the plumule (*p*). It lies upon the ventral side — as regards the pistil — of the hypocotyl, and points toward the base, *i.e.*, in the direction of the arms. The testa (*t*) is formed of a single layer of cells with thick, lignified cell walls, and thus, while it serves, like an arch of bricks, to protect the embryo from outside pressure, it is readily burst open by the swelling within of the hypocotyl.

Perhaps the exposure, and consequent partial drying of the seed, at low tide helps to crack the testa. At any rate, when germination begins the basal end (*h*) of the hypocotyl bursts through the testa and presses the broken edge of it back, leaving a clear passage for the cotyledon. The hypocotyl grows no farther than this, and eventually, when its store of substance has served to give the young plant a start, it dies away.

The cotyledon grows out little beyond the hypocotyl, and is quickly outstripped by the ensheathed plumule, which turns upward and shortly unfolds to the waves several grass-like leaves (Fig. 6). Henceforth it is these leaves only which grow upward; for, except for the slender peduncle which bears the inflorescence, the only stem of the mature Phyllospadix is a creeping rootstock, or rhizome.

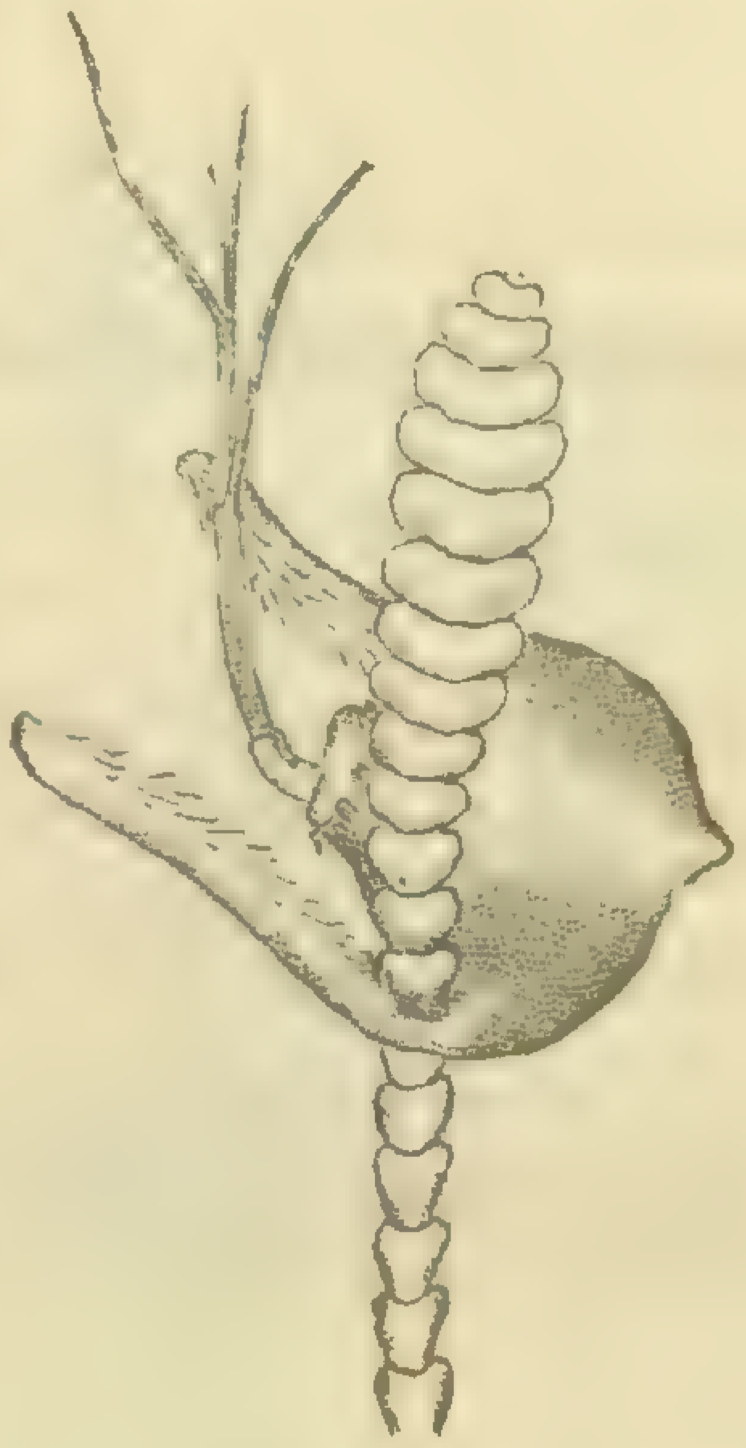

Fig. 6. — Seedling with first leaves.

Our seedling (Fig. 6) has now quite a start in life, and yet it has no root. Its leaves, meanwhile, whipped back and forth by the waves, are gradually beaten to shreds, and replaced by others. In this way several of the first leaves may have lived and died before any root appears. At last, when roots are put forth, there are two of them produced, not from the hypocotyl, as we might expect, but from the stem above the cotyledon (*r*, Fig. 7). That is to say, these are, in the technical sense, adventitious roots. When full grown the roots are about two centimeters long, stout, and unbranched. This first pair hang down, one on either side of the stem, and are soon followed by several more which grow out from the second internode.

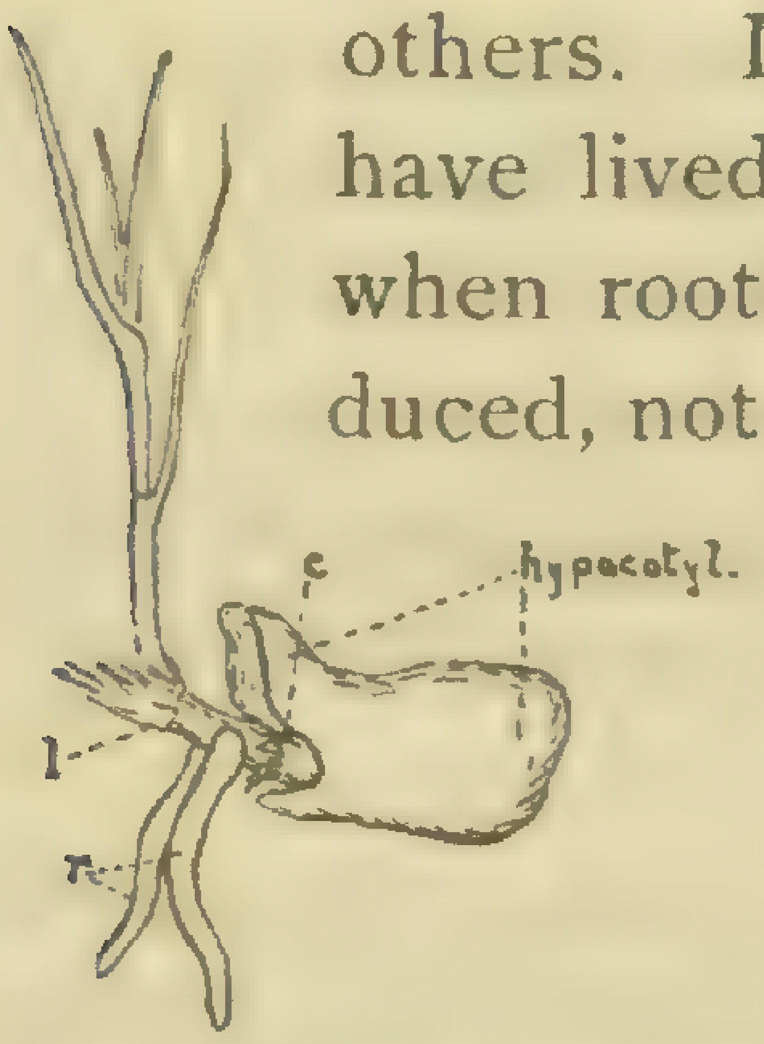

Fig. 7. — Young seedling with coats removed. *c*, insertion and remnant of cotyledon; *l*, second node with remnant of leaf; *r*, roots.

When the roots are several millimeters long they begin to produce, near their tips, a dense, woolly covering of root-hairs, and when a root comes in contact with any object, — be it the stem of the Amphiroa (Fig. 8), the rock

beneath, or another root, — these rhizoidal hairs spread, as a closely adhering film of whitish fibers, over the surface touched, binding the root to it. The root-hairs assume fantastic shapes in order to conform with the irregularities of the rock. If a root has, by chance, entered the loose sand, it becomes enclosed in a compact cylinder of sand, bound together by the myriad of branching, interwoven hairs.

Fig. 8. — Seedling (older) with roots.

The plant has now taken a firm hold on life. Supposing that the start has been made aloft in the branches of the Amphiroa, the elongating stem now dips downward till it strikes the rock. Thenceforth it creeps along, taking, as it goes, a firm grip upon every inch. At each node it bears a leaf, and each of the short internodes produces, on one side a supra-axillary bud, and on the other what Professor Dudley[1] has aptly termed an "epaulette" of six or eight roots; alternating, so that, if one internode has its roots on the right side, the next will have roots on the left. Thus the stem, though in itself weak and brittle, keeps a close, broad grasp upon the rock, while the wiry leaves, buoyed by intercellular air-spaces, stream upward sometimes for a length of two meters. Before these leaves have been whipped to tatters by the waves, their place is supplied with new ones from the lateral buds.

When the rhizome has reached a length of, often, only one or two decimeters, it begins to die away behind. At the same time the lateral buds begin to push out for themselves, so that

[1] *Cf.* Dudley, R. W., in *Zoe*, vol. iv, p. 381.

as the parent stem creeps on it leaves on either side of its trail a series of new rhizomes, starting out at right angles to the old one. In like manner this new generation of rhizomes branch and rebranch, growing over and upon one another, till, in a few years, the bowlders, as well as the bed-rock, are covered by a patch of eelgrass, — a thick mattress, which, as it lies in sinuous tangles at low tide, quite dissipates the force of a hammer, though swung with all the energy of an enthusiastic botanist, and so must, one would think, considerably lessen the effect of the forces which are ordinarily at work reducing the bowlders to pebbles and grinding down the rock itself.

This brings us to the second phase of our subject, namely, the significance of such a plant as Phyllospadix to the geologist. What we wish to show is that under some conditions the effects of the plant in modifying the results of wave and current action are worthy of consideration.

Various geological authorities have commented upon the protection afforded to shore rocks by some marine plants, and upon the accumulation of detritus by others. Certainly no plant is better adapted to either of these functions than Phyllospadix. In the first place its manner of growth is exceptional, resulting, as it does, in the formation of a broad, continuous patch, instead of a scattering of individuals. Again, unlike the soft or rubbery fronds of the algæ, its leaves are strengthened by extremely tough bands of collenchyma fibers.

A moment ago we noticed how the eelgrass bed, the growth of which from a seedling we have sketched, covers the bowlders with a thick mattress which must prevent attrition between the loose stones and pebbles. At Bodega Bay may be seen such a bed, where, at low tide, one may stumble for rods along a bowlder-strewn shore without seeing the rock under foot, all being overlaid by the tangled mat of eelgrass. Now, it might be objected that the corrosive action of the acids excreted by root-hairs would offset the protection the plant might afford to the rock. But it is at once obvious that the root-hairs of Phyllospadix are, in this respect, unlike those of most plants. Their essential function is that of attachment, not nutrition, and, of course, if they should cut the ground from under their

own feet, so to speak, by dissolving away the rock to which they ought to hold fast, they would be useless.

Suppose, now, that a wave-cut terrace, which is being widened by the inroads of the sea, and which is swept by a littoral current bearing the shore-drift along with it, becomes overspread by a growth of coralline algæ. Geike, in his *Text-Book of Geology*, speaks of the preservation of shore rocks by the overgrowth of these corallines ("calcareous nullipores"). These plants cover the substratum with a brittle, calcareous crust, which, though a considerable protection against the cutting of water-borne sand, is shattered by the blow of a pebble. This calcareous enameling retards, to some extent, the lowering of the terrace by the sand-bearing current. That is, while the terrace widens, the water above it may remain comparatively shallow. Moreover, many of these corallines, as Amphiroa and Corallina, produce, in addition to the calcareous crust, numerous erect, jointed fronds; and the latter, as we have seen, offer the best possible lodging place for Phyllospadix. Here, then, we have the conditions most favorable to Phyllospadix, — shallow, but not quiet, water, and corallines to anchor the seeds.

Gradually, if there is eelgrass within drifting distance, the terrace becomes dotted with green tufts, the tufts spread into patches, and ultimately the higher border of the terrace presents, at low tide, the appearance of a wind-laid hay-field, the "grass," one to two meters long, lying in prostrate tangles.

Now begins the accumulation of debris. Stones and pebbles being carried alongshore by the current, odds and ends of seaweeds, and all the multifarious small drift of the shore, are caught in the network of rhizomes and wiry leaves. The larger stones may themselves serve as footholds upon which the rhizomes climb higher and wave their leaves higher in the water. Every stone entangled serves to stop more pebbles and sand, and, as the mass continues to pile up, the rhizomes are at last buried deep under it; but as long as the tips of the leaves wave free the plant thrives. On almost any of our beaches there may be found between tide-lines tufts of slender leaves apparently growing in the sand, but in reality anchored to the rock a meter, perhaps, below.

The result of the accumulations, then, is that the water is made shallower, so that, though the pounding of the heavy seas upon the shore is lessened, the waves still race in over the shallows and carry up the smaller particles to deposit them on the beach. At the same time, even though the littoral drift be not held permanently by the eelgrass, yet the time required for it to pass the place, and hence its chance of contributing to the beach, is increased.

Shoaler and shoaler grows the water, the shore line advancing as a low beach, and finally, — the littoral current being deflected seaward and the wave deposition continuing, — the terrace that was is overlaid by a sand-flat.

That the long, hemp-like fibers of eelgrass lend coherence to the mass of sand and stones in which they are imbedded is attested by the fact that where, as above, we find a clump of eelgrass half-buried in the sand, the level of sand within the clump is often several inches above that of the surrounding beach.

In closing, and to recapitulate, it seems probable that the spreading over a terrace of such a plant as Phyllospadix must tend, first, to protect the rocks from erosion and attrition; second, to help, by trapping the shore-drift, to raise the terrace so as to form a beach, or a sublittoral sand-flat; and last, by binding together its materials, to render the foundation of the beach, once formed, more coherent and stable.

University of California, Berkeley, Cal.,
May, 1900.

A QUANTITATIVE STUDY OF VARIATION IN THE BRACTS, RAYS, AND DISK FLORETS OF ASTER SHORTII HOOK., A. NOVÆ-ANGLIÆ L., A. PUNICEUS L., AND A. PRENANTHOIDES MUHL., FROM YELLOW SPRINGS, OHIO.[1]

GEORGE HARRISON SHULL.

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I. Introduction.

The work upon which this paper is based was done in the Biological Laboratory of Antioch College, during the academic year 1900–1901, under the direction of Prof. W. L. Tower.

My primary object was to study the variations of several species of Aster by means of the statistical methods, to determine whether the results of Ludwig ('95, '96, '98) upon *Chrysanthemum leucanthemum* L. were also true for other nearly allied forms, and to find out, if possible, how much correlation there

[1] *Contributions from the Biological Laboratory of Antioch College*, No. 5.

is between the observed variation and the environment, or between parts of the same plant. Secondarily, it was hoped that this research might show something of the applicability of these methods to taxonomic or monographic work in a genus so difficult from the systematic standpoint as Aster.

II. Material.

This consisted of the blooming capitula of *Aster shortii* Hook., *A. novæ-angliæ* L., *A. puniceus* L., and *A. prenanthoides* Muhl.

The capitula were cut off without any conscious selection, folded in papers, labeled, and preserved in alcohol. With the exception of those plants where series of pickings were made, the stems from which the capitula had been gathered were preserved for future reference.

All of the species of Aster studied are perennial, but they differ in the manner in which the annual stems are produced. In the following description of the material used in this study I shall use the term "individual" in its broader sense, including all stems which have been derived from a single seed.

Aster shortii Hook. has from one to three or four slender annual stems arising from a small perennial root. The material which forms the basis for the study of this species was obtained Sept. 26, 1900, and consisted of 226 capitula from three isolated individuals and from a group of ten stems growing near to each other. The stems of this group were probably mostly distinct individuals, though they may have been of close genetic relationship. These plants grew in the thin limestone soil at the foot of the Niagara limestone cliffs bordering the northern end of Sheldon's Glen, one-half mile southeast of Yellow Springs, Ohio.

Aster novæ-angliæ L. has a heavy mass of perennial roots, and from the base of the annual stems of one year's growth may arise a considerable number of heavy stems of the next year's growth, forming a clump. The 199 capitula used in the study of this species were collected Sept. 30, 1900, from five individuals growing in the flood plain of a tributary to the Glen

Stream, one-half mile east of Yellow Springs, and from four individuals similarly located in the valley of the Glen Stream about forty rods above the point at which it empties into the Little Miami River, one mile southeast of Yellow Springs, Ohio.

The manner of production of annual stems in *Aster puniceus* L. resembles closely that of *Aster novæ-angliæ* L. The material of *Aster puniceus* L. used in this study was collected Sept. 25, 1900. It consisted of 798 capitula from thirteen stems arising from three perennial roots growing at the margin of a bog five miles west of Yellow Springs, Ohio. These three individuals were identically located, being separated by a space of but a few yards. Environmental conditions had, therefore, no known influence in determining the differences in the heads from the three clumps.

Aster prenanthoides Muhl. differs from all of the other species studied, in the manner in which its annual stems are produced. It sends out slender rootstocks, which give rise to new stems at a little distance from the old ones, thus forming patches with the stems growing singly.

Eighty-three capitula of *Aster prenanthoides* Muhl. were collected Sept. 27, 1900, from seven stems, apparently belonging to two individuals. The remaining material of this species, making a total of 658 capitula, was all collected from a single small plot. Four successive collections were made on September 27, September 30, October 4, and October 8, 1900. All the capitula which were blooming at the time of each collection were taken, amounting respectively to 117, 143, 139, and 176 heads, and comprising all the heads produced by the selected plot during the season. The object in collecting in this way was to test, at least within narrow limits, the constancy of the variability "constants" throughout the flowering season.

The plants from which all the material of *A. prenanthoides* Muhl. was collected grew at the bottom of a small ravine near Clifton, Ohio, at the margin of a permanent stream, so that heat, light, soil, and moisture conditions were nearly constant throughout the growing period.

III. METHODS AND PRECAUTIONS.

In order that the personal equation should modify results as little as possible, all of the heads of each individual were collected, and none were discarded on the ground of abmodality. The only material rejected was such as was eaten by insects, or had been blighted to such extent as to make a correct count impossible. It is evident that by the discarding of healthy material because of its great departure from the usual condition, or, as Strong (**1901**, p. 295) says, the choice of "individuals which appear on inspection to be typical," the statistical method may be made to give any result for which the investigator may be looking.

There is one element of error in the choice of material which must be mentioned. In those cases in which it seemed desirable to get curves and "constants," representing the conditions in the capitula of single individuals, there was necessarily a choice of those individuals which had the largest number of blooming heads. In this respect, therefore, the determinations would represent the conditions in the more robust specimens rather than in the general population. To counteract this tendency, there was an occasional collection of material from a sufficiently large group of smaller individuals to give equally valid results. As these collections from a number of smaller individuals did not show a marked difference from those of single larger individuals, this selection has probably not greatly modified the results.

In making counts the liability of error is not so great as in the taking of measurements. However, even in counting there are sources of error, which I found it necessary to eliminate as far as possible. To free my work as far as possible from these sources of error, the capitula were carefully dissected and the parts kept separate until the count was completed. When there was the least doubt as to the correctness of the result they were recounted. Also in cases of great abmodality the results were verified by a recount.

In calculating the various constants I have used the formulæ given by Davenport (**'99**). All the mathematical processes

were carried out to the tenth decimal place, and wherever practicable they were checked. It is probable, therefore, that all calculations are correct to the fifth decimal place.

In plotting the variations I have used the "method of rectangles" as best representing the actual conditions found. In those cases in which material was insufficient compared with the range of variation, I have doubled the classes, but in no case have I grouped more than two classes together. In this way the essential features of the curves have remained unchanged, while the lesser irregularities have been eliminated.

It must be remarked, however, in regard to the grouping of classes, that the method should be used with much caution. By combining a sufficient number of classes every multimodal curve may be made monomodal.

It is also essential, in doubling, that a definite plan be adopted in order that the results may be comparable. The writer followed the plan of throwing together the two classes nearest the mean. As the mean is a constant, this makes the resulting double classes of the various curves strictly comparable. If I had begun at the lower limit of range instead of at the mean, the count of one more variate might have lowered the range by one, and thus have changed the combinations, with the result that the character of the curve might be much modified.

IV. Results.

Aster shortii Hook. — Fig. 1 represents the frequency polygon of the bracts. The range, 28 to 49, was so great that the 226 counts were insufficient, and it was deemed best to double the classes. In this way the curve becomes monomodal, with the mode on 36–37, and the mean on 36.800884. The coefficient of variability was 10.727157.

The frequency curve of the rays (Fig. 2) shows a remarkably strong mode on 13, 38 per cent of the variates falling into that class, with the mean on 14. This strong mode on 13 suggests at once Ludwig's ('95, '96, '98) interesting results on *Chrysanthemum leucanthemum* L., etc.; but, as nowhere else in the Asters studied has there been any apparent tendency of modes

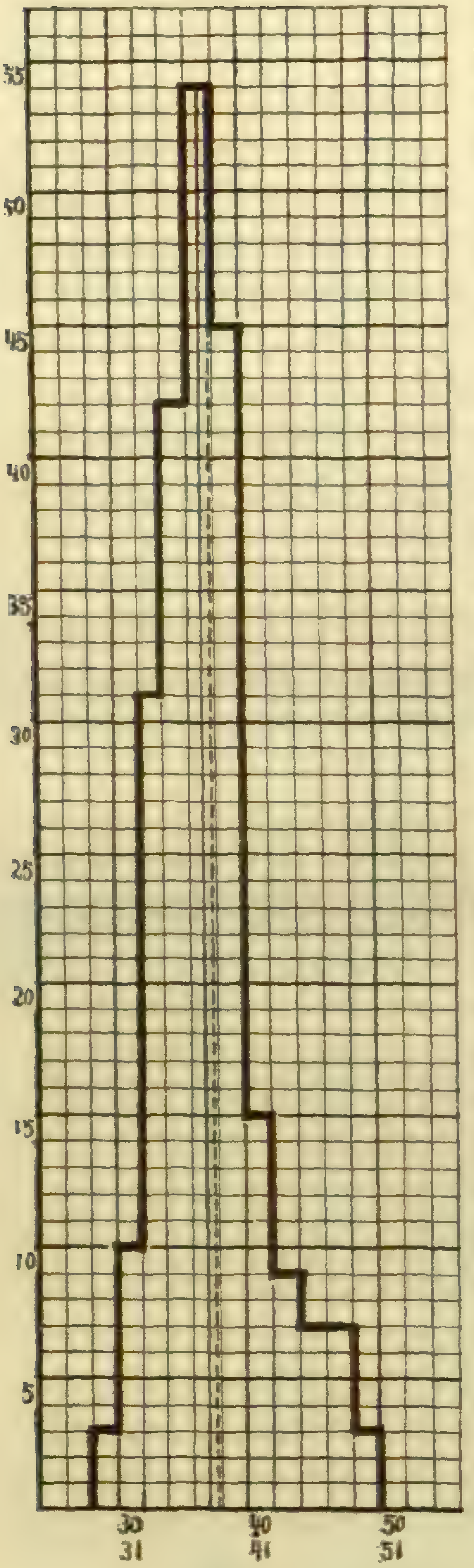


Fig. 1.

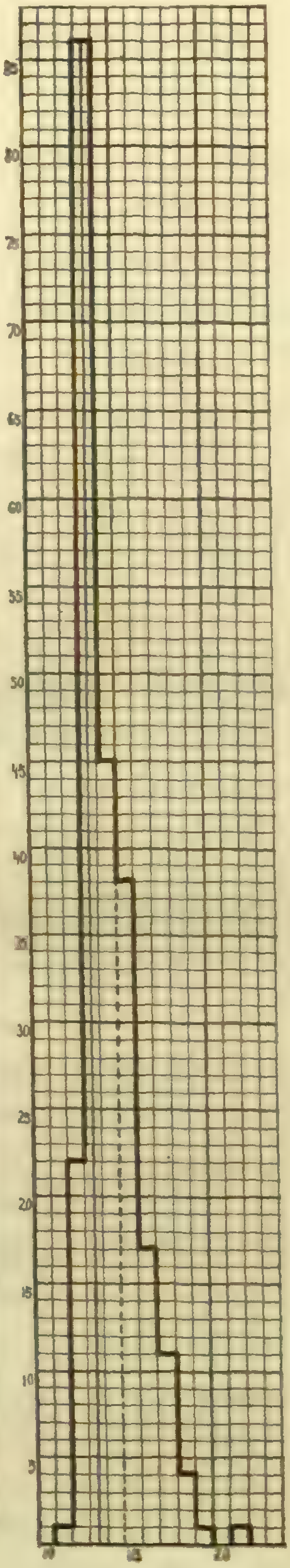


Fig. 2.

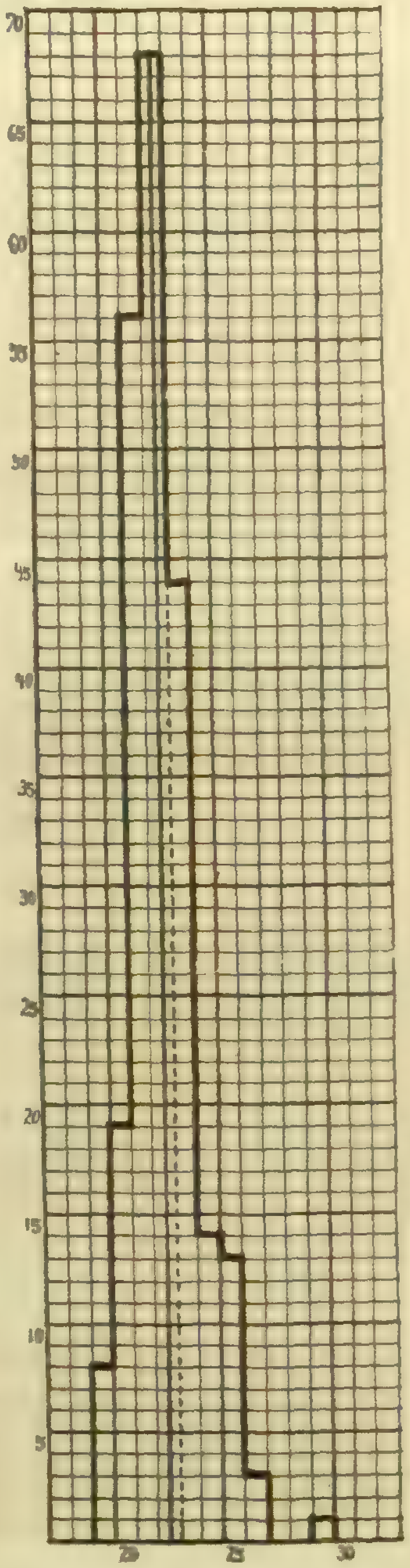


Fig. 3.

Fig. 1. — *Aster shortii* Hook. Bract curve of 226 heads. Classes doubled. Mean = 36.800884 ± .177121; mode = 36–37; σ = 3.947688 ± .125243.

Fig. 2. — *Aster shortii* Hook. Ray curve of 226 heads. Mean = 14 ± .068448; mode = 13; σ = 1.525592 ± .048400.

Fig. 3. — *Aster shortii* Hook. Disk curve of 226 heads. Mean = 22.053097 ± .067885; mode = 22; σ = 1.513025 ± .048001.

to fall into the series 8, 13, 21, 34, etc., this condition in *Aster shortii* Hook. cannot be considered as having any special sig-

	X_2	−8	−7	−6	−5	−4	−3	−2	−1	0	0	1	2	3	4	5	6	7	8	9	10	11	12
X_1		28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49
−3	11											1											
−2	12				1	1	2	3	4	3	4	3	1				1						
−1	13		1	3	2	9	4	7	7	18	10	8	9	6	1								
0	14	1		1		2	4	5	2	4	4	6	10	3	2		1						
1	15		1	1	2	4	1	2	5	3	6	1	4			2	1	3		2			
2	16					3	1		3				2	2		1	1	1	1			2	
3	17							3	1	1	1				1	1				3			
4	18															1			1		1		1
5	19																		1				
6	20																						
7	21																				1		

FIG. 4. — *Aster shortii* Hook. Correlation surface for 226 heads. Rays subject and bracts relative. $\rho = .549555 \pm .025157$.

	X_2	−3	−2	−1	0	0	1	2	3	4	5	6
X_1		19	20	21	22	23	24	25	26	27	28	29
−3	11					1						
−2	12		1	7	6	7	1					
−1	13	3	2	23	37	18	2	1				
0	14	3	6	8	13	8	5	2				
1	15	2	4	12	6	5	2	5	2			
2	16		4	4	1	2	2	3	1			
3	17		2	1	2	3	2	1				
4	18			1	2							1
5	19				1							
6	20											
7	21							1				

FIG. 5. — *Aster shortii* Hook. Correlation surface for 226 heads. Rays subject and disk florets relative. $\rho = .446645 \pm .029861$.

nificance in this connection. The coefficient of variability for the rays was found to be 10.897091, or a little greater than that of the bracts.

The curve of the disk florets (Fig. 3) in this species shows a remarkable lack of variation in parts which, owing to their indeterminate character, might be expected to be the most variable. The mode is on 22, the mean on 22.053097, and the coefficient of variability is only 6.860830. It should be noted that in all these curves there is negative skewness,[1] though it is slight in the bracts and disk florets. The variability constants for *Aster shortii* Hook. are shown in the following table.

TABLE A. — CONSTANTS OF ASTER SHORTII HOOK.

	BRACTS.	RAYS.	DISK FLORETS.
No.	226	226	226
Mean	36.800884	14	22.053097
Mode	36–37	13	22
A. D.	3.029211	1.176991	1.115200
σ	3.947688	1.525592	1.513025
P. E. A. D.	± 2.662716	± 1.029012	± 1.020535
P. E. M.	± .177121	± .068448	± .067885
P. E. σ	± .125243	± .048400	± .048001
C. V.	10.727157	10.897091	6.860830

In Fig. 4 is represented a "correlation surface" with rays subject and bracts relative. The coefficient of correlation was found to be .549555 (P. E. $\rho = \pm$ .025157). The correlation between rays and disk florets is shown in Fig. 5, in which the coefficient of correlation is .446645 (P. E. $\rho = \pm$ .029861).

Aster novæ-angliæ L. — In this species the range of variation in all the parts was great, the least range, 30 to 60, occurring in the bracts.

All the frequency polygons, Figs. 6, 7, and 8, show a multimodal condition, but this may be due to too scanty material. Although no dependence can be put upon the multimodal condition of these curves, the "variability constants" will perhaps not differ widely from results which would be given

[1] The degree of skewness has not been computed for any of the polygons of distribution because the range of material was too small to make this index of any value.

by counting larger quantities of the same material. These appear in the following table.

TABLE B. — CONSTANTS OF ASTER NOVÆ-ANGLIÆ L.[1]

	BRACTS.	RAYS.	DISK FLORETS.
No.	199	199	199
Mean	44.030150	42.874371	62.452261
Modes	33, 37, 43, 47, 57	37, 43, 47, 51	51, 60, 63, 70
A. D.	4.111310	5.048407	7.688088
σ	5.212961	6.308112	9.314270
P. E. A. D.	± 3.516142	± 4.254822	± 6.282475
P. E. M.	± .249252	± .301616	± .445352
P. E. σ	± .176248	± .213267	± .314912
C. V.	11.839527	14.710682	14.914224

There is a high degree of correlation between rays and bracts (Fig. 9), which is the more apparent because of the close agreement in the number of rays and bracts; 10.54 per cent of all the capitula had the number of rays and bracts equal. The coefficient of correlation between these was .802388 ± .012685. Between rays and disk florets the correlation (Fig. 10) was much lower, the coefficient being .594798 ± .024859.

Aster puniceus L. — The polygons of distribution of the bracts (Fig. 11), rays (Fig. 12), and disk florets (Fig. 13) of *Aster puniceus* L. are all multimodal; but it would not be fair to assume that this condition is a specific one, for, although the number of variates was 798, they represent only three individuals, and these individuals had an exceedingly wide range of variation and also differed widely in the values of their "constants." These facts will be best appreciated by a study of the table on the following page.

[1] The table of constants for *Aster novæ-angliæ* L. is presented because the multimodal condition of the polygons of distribution of this species may be due to too limited material. If more material shows this same condition, then all the constants except the mean and mode must be dropped from this table. The same is also true for the constants for all of the species given in this paper.

TABLE C. — CONSTANTS OF ASTER PUNICEUS L.

		INDIVIDUAL No. 1. 337 heads.	INDIVIDUAL No. 2. 246 heads.	INDIVIDUAL No. 3. 215 heads.	SUMMATION, Nos. 1, 2, and 3. 798 heads.
BRACTS.	Mean . . .	42.501483	45.378048	46.795348	44.546365
	Modes . .				35, 39, 49, 46, 48
	A. D. . . .	3.965747	3.140095	2.377501	3.571510
	σ	4.760197	3.959072	3.035446	4.497254
	P. E. A. D.	± 3.210752	± 2.670394	± 2.047408	± 3.033397
	P. E. M. . .	± .174901	± .170258	± .139632	± .107381
	P. E. σ . .	± .123673	± .120390	± .098734	± .075929
	C. V. . . .	11.200072	8.724641	6.486640	10.095669
RAYS.	Mean . . .	35.020771	36.321138	39.660465	36.671679
	Modes . .				27, 35, 37
	A. D. . . .	3.039368	3.421607	3.175164	3.577188
	σ	3.904214	4.297721	4.018685	4.480251
	P. E. A. D.	± 2.633392	± 2.898813	± 2.710603	± 3.021929
	P. E. M. . .	± .143450	± .184821	± .184861	± .106975
	P. E. σ . .	± .101434	± .130688	± .130716	± .075642
	C. V. . . .	11.148282	11.832838	10.132723	12.217198
DISK FLORETS.	Mean . . .	60.513353	76.609756	74.241860	69.174185
	Modes . .				57–58, 63–64, 67–68, 73–74, 79–80
	A. D. . . .	5.805756	8.068609	5.644478	8.947764
	σ	7.338405	10.083765	7.115330	11.116989
	P. E. A. D.	± 4.949754	± 6.801500	± 4.799290	± 7.498400
	P. E. M. .	± .269630	± .433647	± .327308	± .265440
	P. E. σ . .	± .190657	± .306628	± .231442	± .187694
	C. V. . . .	12.126919	13.162508	9.583987	16.071008

This work on *Aster puniceus* L. shows what a wide difference may exist, even in such constants as the means, standard deviations, and coefficients of variability, in individuals growing under apparently identical conditions.

In Fig. 14 is shown the correlation surface for rays and bracts of all the heads counted. The coefficient of correlation was .705100 ± .009194, while that for rays and disk (Fig. 15) was .674928 ± .010045.

Aster prenanthoides Muhl. — The frequency polygons for all the heads counted in this species are shown in Figs. 16, 17, and 18. All are multimodal, but by doubling the classes in Fig. 17, which represents the variation in the rays, the curve becomes monomodal with negative skewness, the mode being on 26–27 and the mean on 28.037993.

Doubling the classes in Fig. 16 still leaves three modes in the frequency polygon of the bracts. These modes occur on

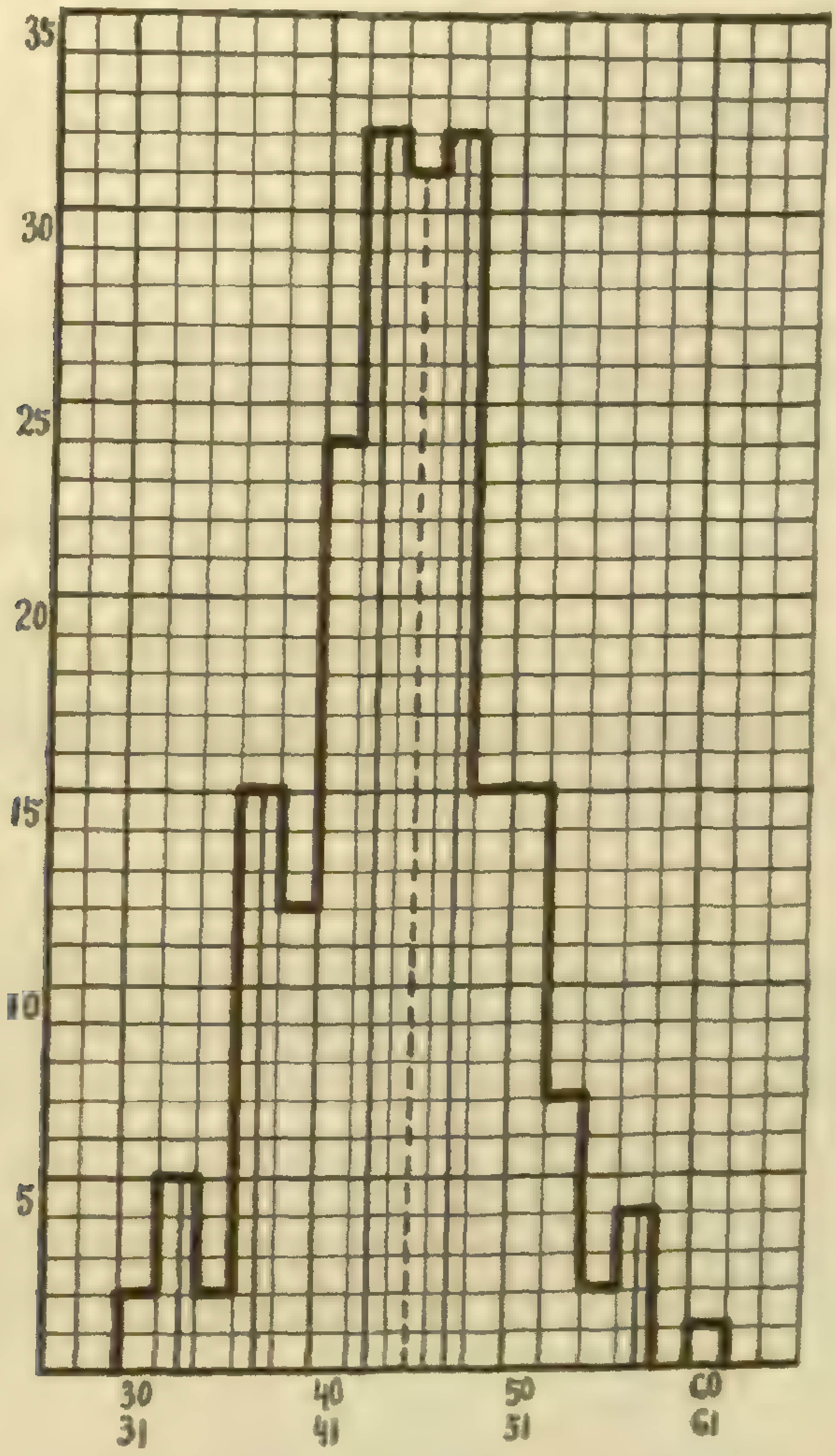


FIG. 6. — *Aster novæ-angliæ* L. Bract curve of 199 heads. Classes doubled. Mean = 44.030150 ± .249252 ; modes = 33, 37, 43, 47, 57 ; σ = 5.212961 ± .176248.

40–41, 44–45, and 48–49. Fig. 18 shows the curve of the disk florets to have two nearly equal modes on 48–49 and 52–53.

The correlation of rays and bracts in the 658 capitula counted (Fig. 19) is expressed by the coefficient .776834 ± .007820, and that of the rays and disk florets (Fig. 20) by .770316 ± .008042.

Table D. — Constants of Aster prenanthoides Muhl.

	Bracts.	Rays.	Disk Florets.
No.	658	658	658
Mean	44.044072	28.037993	50.297872
Mode	40–41 44–45 48–49	26–27	48–49 52–53
A. D.	4.497002	3.373227	4.884951
σ	5.716510	4.070071	6.310315
P. E. A. D.	± 3.855786	± 2.745263	± 4.256308
P. E. M.	± .150314	± .107021	± .165889
P. E. σ	± .106288	± .075675	± .117301
C. V.	12.979068	14.516272	12.545890

Result of the Successive Collections. — The remaining figures represent the conditions found in four successive pickings made from a single group of individuals of *Aster prenanthoides* Muhl.

1. *Bracts.* Figs. 21, 22, 23, and 24 show the frequency polygons of the bracts in the successive collections. In the first collection (Fig. 21) there was a single mode on 49–50, with the mean on 47.410256 and a strong positive skewness. In the second collection (Fig. 22) the curve broke up into three modes on 40–41, 44–45, and 48–51, while the mean fell to 44.342657. In the third collection (Fig. 23) the material exhibited two modes on 44–45 and 50–51, which correspond closely with the upper two modes of the second picking, the mean having fallen to 43.834532. At the last collection the curve, given in Fig. 24, showed a strong mode on 41–42, while the upper mode, which at this time occurred on 49–50, had become much less prominent, and a small mode had appeared on 33–34. The mean had continued to fall, and in this last collection was only 41.92045.

The table on page 124 will facilitate a comparison of the bracts from the four collections.

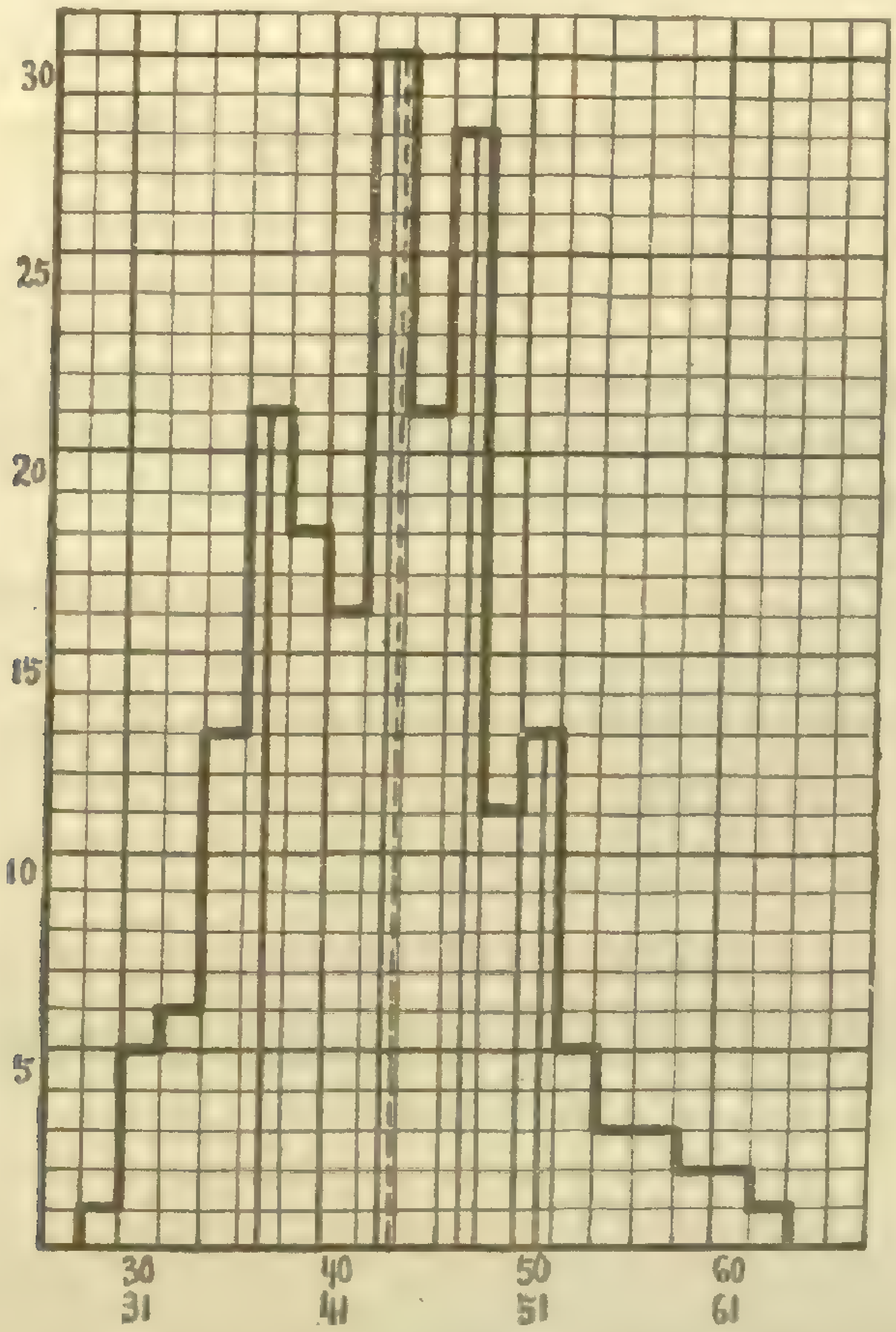


FIG. 7. — *Aster novæ-angliæ* L. Ray curve of 199 heads. Classes doubled. Mean = [illegible] ± .301616; modes = 37, 43, 47, 51; σ = [illegible] ± .213267.

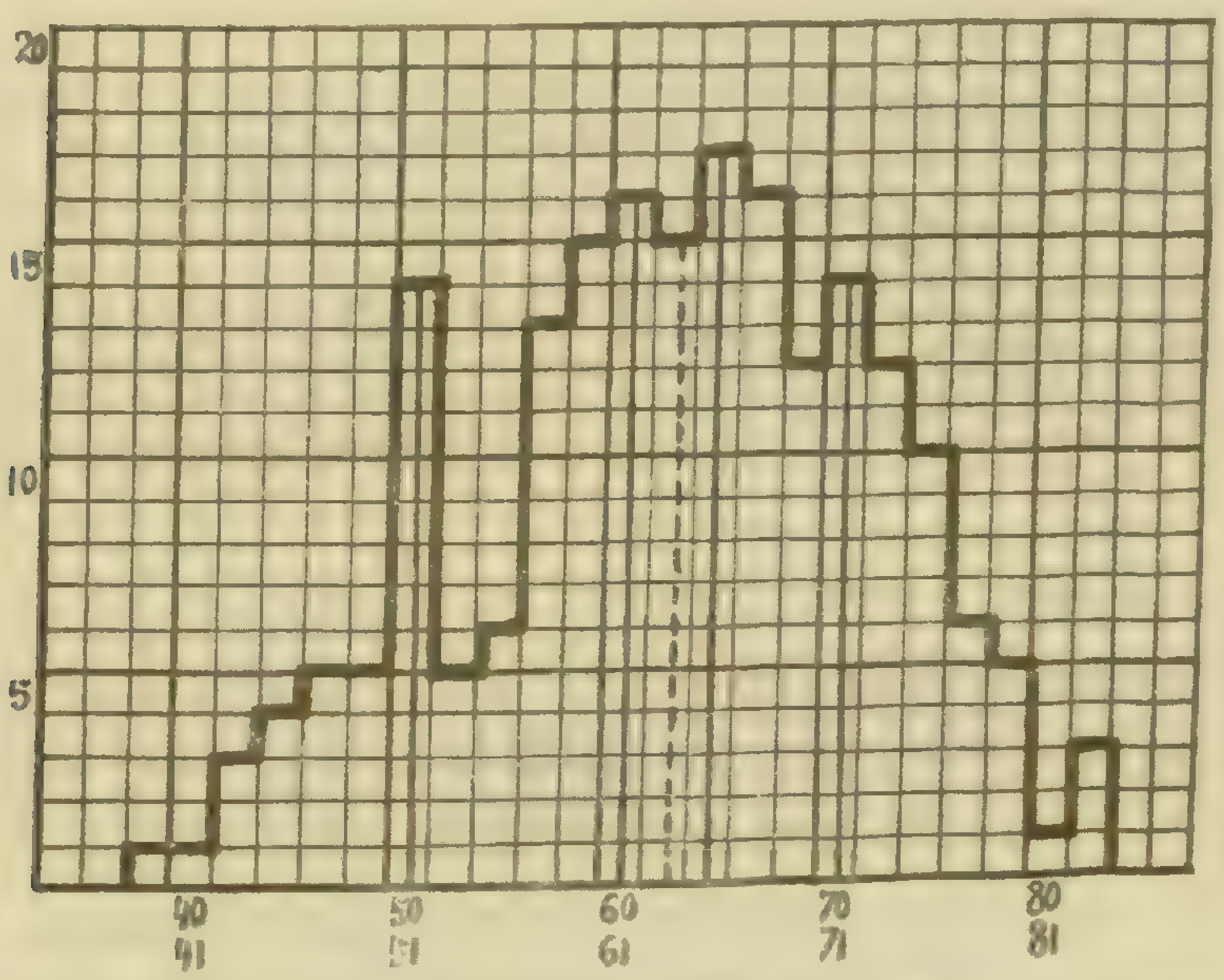


FIG. 8. — *Aster novæ-angliæ* L. Disk curve of [illegible] heads. Classes doubled. Mean = [illegible] ± .445352; modes = 51, 60, 63, 70; σ = 9.314270 ± .314912

TABLE E. — CONSTANTS OF BRACTS OF FOUR PICKINGS OF ASTER PRENANTHOIDES MUHL.

	117 CAPITULA, COLLECTED SEPTEMBER 27.	143 CAPITULA, COLLECTED SEPTEMBER 30.	139 CAPITULA, COLLECTED OCTOBER 4.	176 CAPITULA, COLLECTED OCTOBER 8.
Mean	47.410256	44.342657	43.834532	41.92045
Mode	49–50	40–41 44–45 48–51	44–45 50–51	33–34 41–42 49–50
A. D.	4.350646	4.256345	4.308211	3.855552
σ	5.524237	5.152370	5.275976	4.889626
P. E. A. D.	± 3.726098	± 3.475273	± 3.558646	± 3.298052
P. E. M.	± .344540	± .290617	± .301840	± .248600
P. E. σ	± .243626	± .205497	± .213433	± .175786
C. V.	11.651989	11.619444	12.036119	11.664053

2. *Rays.* The frequency polygon for rays from the first collection (Fig. 25) shows a strong mode on 32–35 and a lesser mode on 26–27. The mean of this collection was 30.769230. In the second collection (Fig. 26) the principal mode had fallen to 30–33, filling up the sinus and forming a monomodal curve. The mean had also fallen to 28.706293. In the third collection the rays again broke up into a multimodal condition, as shown in Fig. 27. The modes of this curve are on 24–25, 28–29, and 32–33, and the mean on 28.251798. In the fourth collection the rays again exhibited a strongly monomodal condition (Fig. 28), with the mode on 26–27, while the mean had fallen to 26.335227.

3. *Disk Florets.* In Fig. 29 is shown the multimodal frequency polygon for the disk florets of the first collection, with modes on 56–57 and 60–61, and the mean on 56.427350. In the second collection (Fig. 30) modes occurred on 45–46 and 51–52, and the mean had fallen to 51.713286. In Fig. 31 is represented the variation of the disk florets of the third collection. The curve is monomodal and nearly normal, the mode occurring on 49–50 and the mean on 49.158273. The disk curve of the fourth collection (Fig. 32) is also strongly monomodal and nearly normal, but the mode has fallen to 45–46 and the mean to 45.778409.

	X_2	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
X		30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
-13	29	1																														
-12	30				1																											
-11	31		1		1		1	1																								
-10	32				1				1																							
-9	33				1			1			1	1																				
-8	34					1			1	2	1				1																	
-7	35								4		1		2																			
-6	36				1				1			4	2	2																		
-5	37							2	3		1			4		1																
-4	38											1	1	2	1		2															
-3	39									1	2	1			1	1	3	1			1											
-2	40													1	3	3																
-1	41								1		1		2	2		1	1			1												
0	42										1	1	2	1	3			3	1		1											
0	43										1	1		1	1	1	5	4	2		1											
1	44											1	1		1		2	2	2			1										
2	45															1	2	2	2	1	3											
3	46												1	2	1	1	3	2	4	1		1		1								
4	47											1	2			1			1			2	1	1	1		1					
5	48														1			1	1		1		1									
6	49																1	1	2					1			1					
7	50												1						1	2	1	2	1		1							
8	51													1								1	1		1							
9	52																				1							1				
10	53													1								2										
11	54																				1		1									
12	55														1																	
13	56																1							1				1				
14	57																															
15	58																1															1
16	59																															
17	60																											1				
18	61																											1				
19	62																															
20	63																						1									

Fig. 9. — *Aster novæ-angliæ* L. Correlation surface for 199 heads. Rays subject and bracts relative. $\rho = .802388 \pm .012685$.

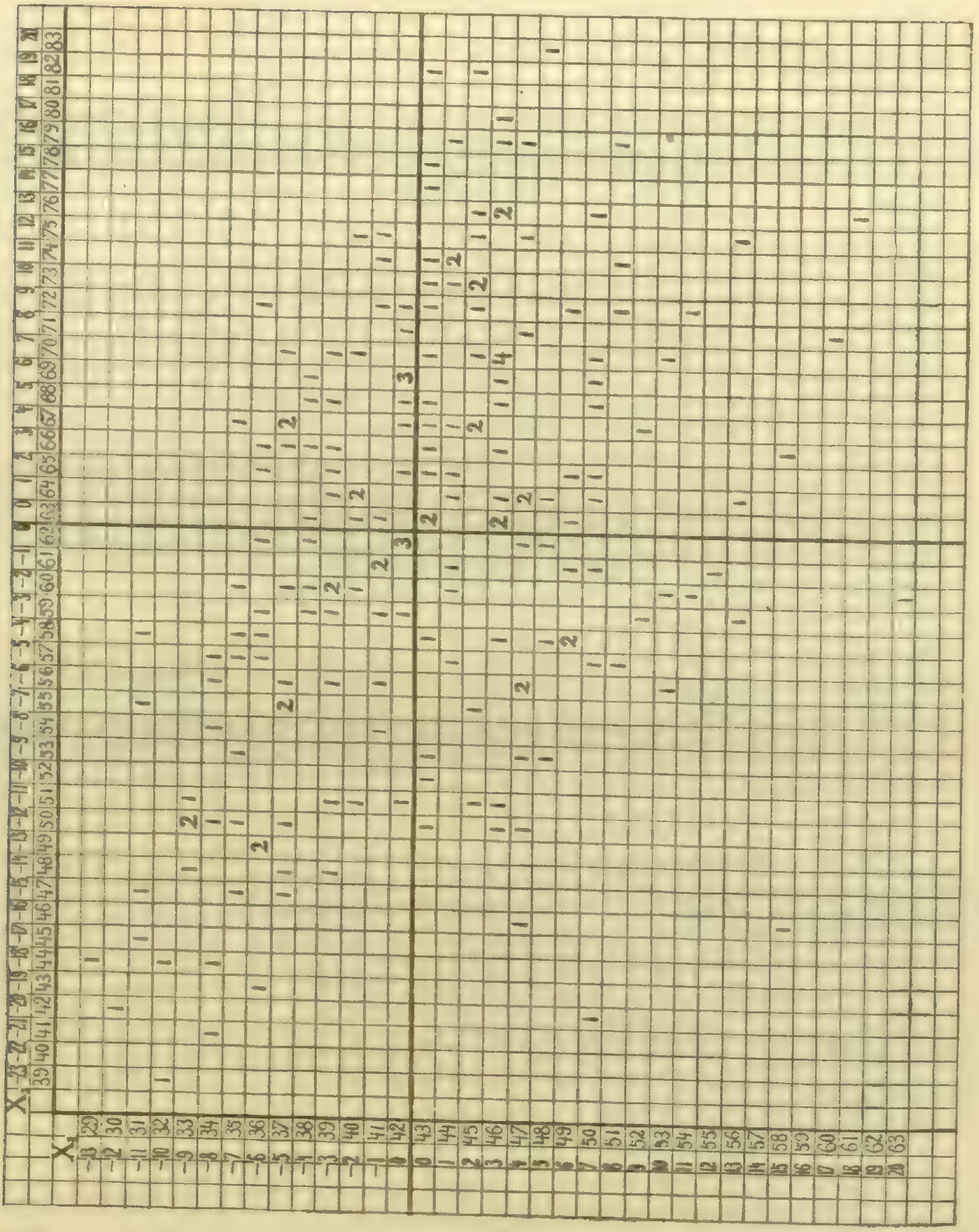


FIG. 10. — *Aster novæ-angliæ* L. Correlation surface for 109 heads. Rays subject and disk florets relative. $\rho = .594798 \pm .024859$.

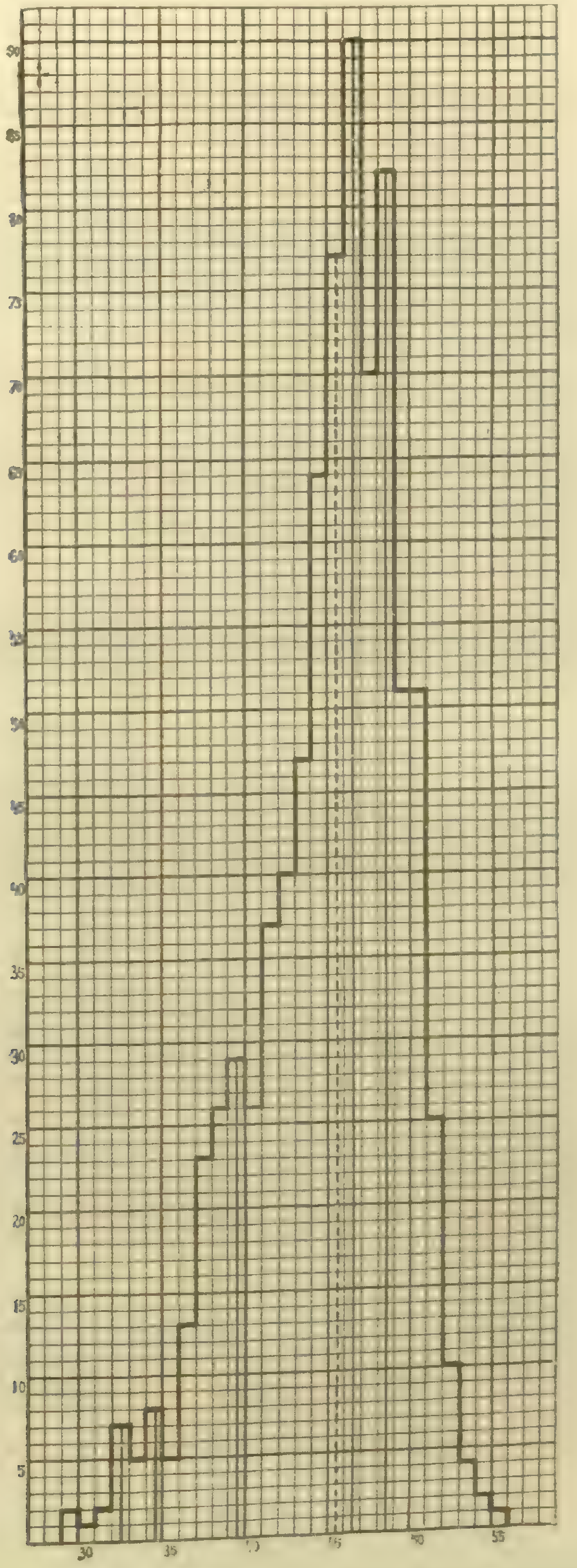


Fig. 11. — *Aster puniceus* L. Bract curve of 798 heads. Mean = 44.546365 ± .107381 : modes = 32, 35, 39, 46, 48 ; σ = 4.497254 ± .075929.

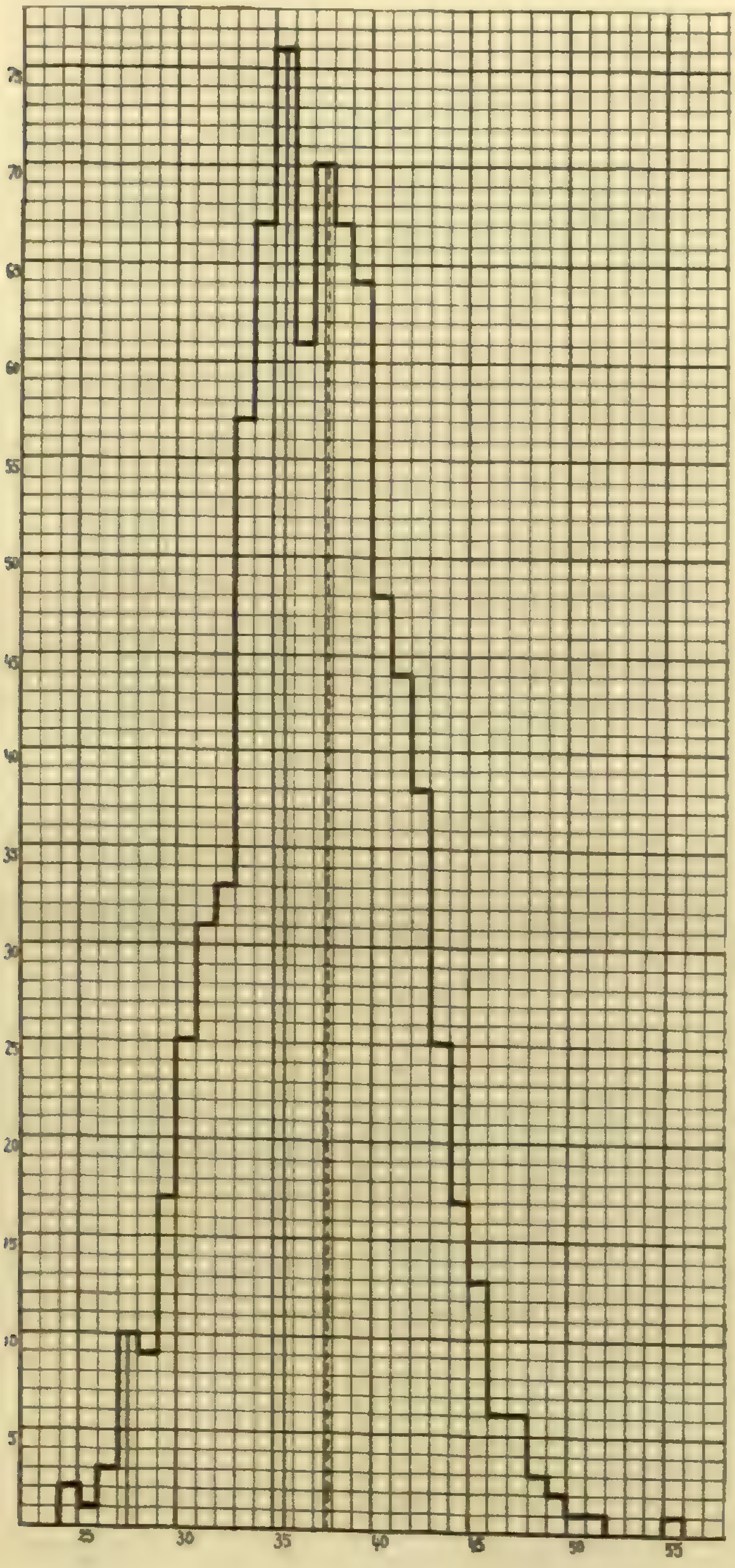


FIG. 12.—*Aster puniceus* L. Ray curve of 798 heads. Mean = $36.671679 \pm .075642$; modes = 27, 35, 37; $\sigma = 4.480251 \pm .075642$.

FIG. 13. — *Aster puniceus* L. Disk curve of 798 heads. Classes doubled. Mean = 69.174185 ± .265440 ; modes = 57–58, 63–64, 67–68, 73–74, 79–80 ; σ = 11.116989 ± .187694.

X_1		X_2: −15	−14	−13	−12	−11	−10	−9	−8	−7	−6	−5	−4	−3	−2	−1	0	0	1	2	3	4	5	6	7	8	9	10
		29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55
−12	24		1				1																					
−11	25						1																					
−10	26			1							1				1													
−9	27			1		1		3	2	1		1	1															
−8	28	1			1			1	1			1	2						1		1							
−7	29	1			2		2			4	3	2				3												
−6	30				1	1	1			5	3	3	2		3	2	2	1	1									
−5	31				2	1			2	4	2	3	3	2	4	4		1	3									
−4	32				1	1			2	1	5	3	2	5	3	5	2		1	2								
−3	33					1	1			4	5	6	6	4	9	4	6	7	3		1							
−2	34						2	1	2	1	2	4	2	7	2	9	11	6	5	6	2	4			1			
−1	35								3	1	3	3	5	10	7	8	7	7	7	3	8	2	1	1				
0	36									2	2	2		3	4	4	6	5	16	6	4	3	2	1		1		
0	37								1			1		2	4	4	4	11	11	9	10	6	7					
1	38												1	2	1	2	7	10	10	15	7	4	3	4		1		
2	39												2			2	8	13	13	4	11	3	5	2	1			
3	40													1	1		5	5	4	5	6	7	7	5	2			
4	41													1			2	2	5	5	10	5	5	5	3			
5	42														1		3	4	2	8	9	6	2	3				
6	43																	2	3	3	5	4	4	2	2			
7	44																	1	1	1	4	1	9					
8	45																1		2	2	2	3	2	1				
9	46																	1			1	1	3					
10	47																			1	1	2			1		1	
11	48																		1				1					1
12	49																									1	1	
13	50																		1									
14	51																							1				
15	52																											
16	53																											
17	54																											
18	55																									1		

FIG. 14. — *Aster puniceus* L. Correlation surface for 798 heads. Rays subject and bracts relative.
$\rho = .705100 \pm .009194$.

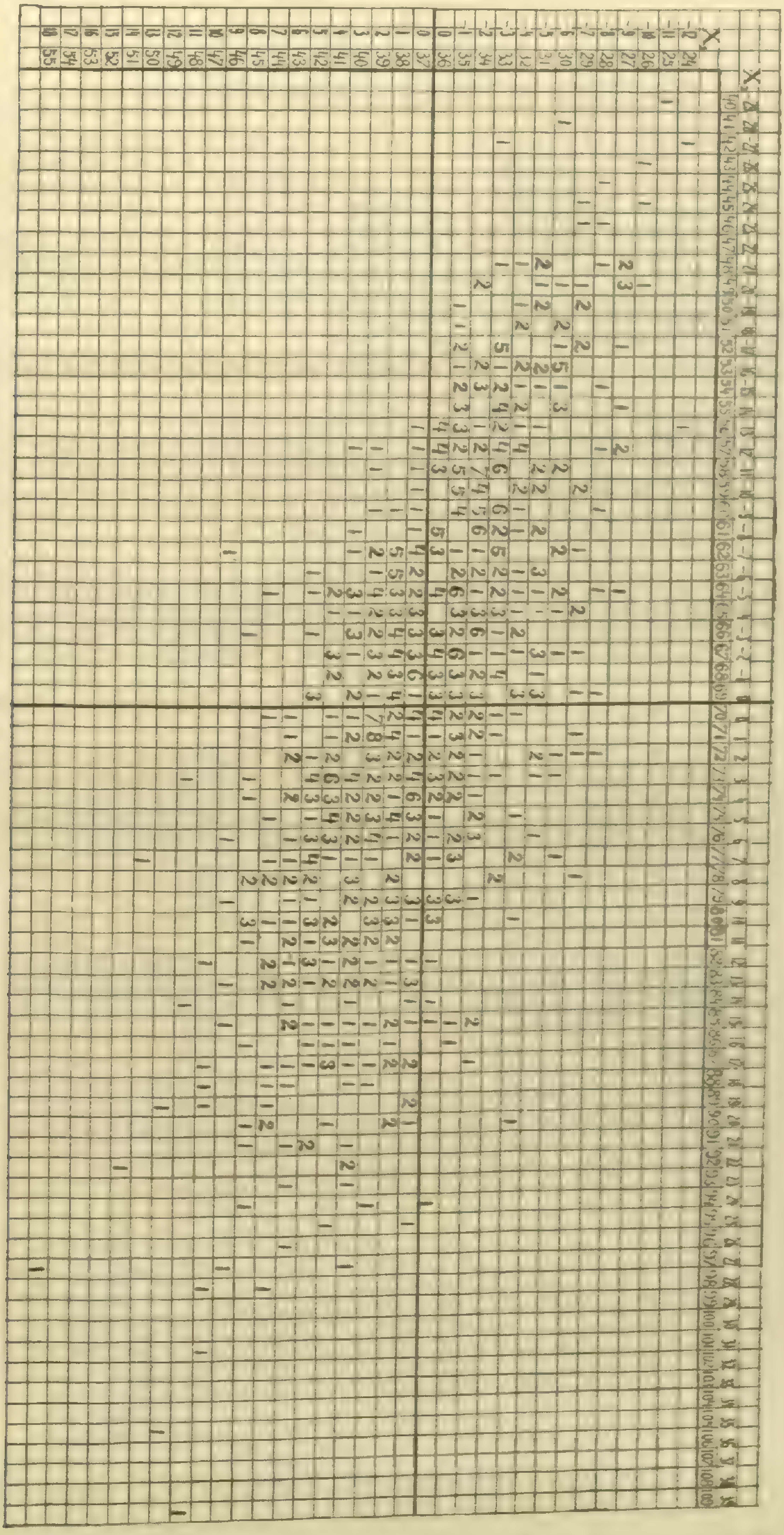


Fig. 15. — *Aster puniceus* L. Correlation surface for 798 heads. Rays subject and disk florets relative. $\rho = .674928 \pm .010045$.

FIG. 16. — *Aster prenanthoides* Muhl. Bract curve of 658 heads. Mean = 44.044072 ± .150314; modes = 32, 34, 39, 41, 43, 49; σ = 5.716510 ± .106288.

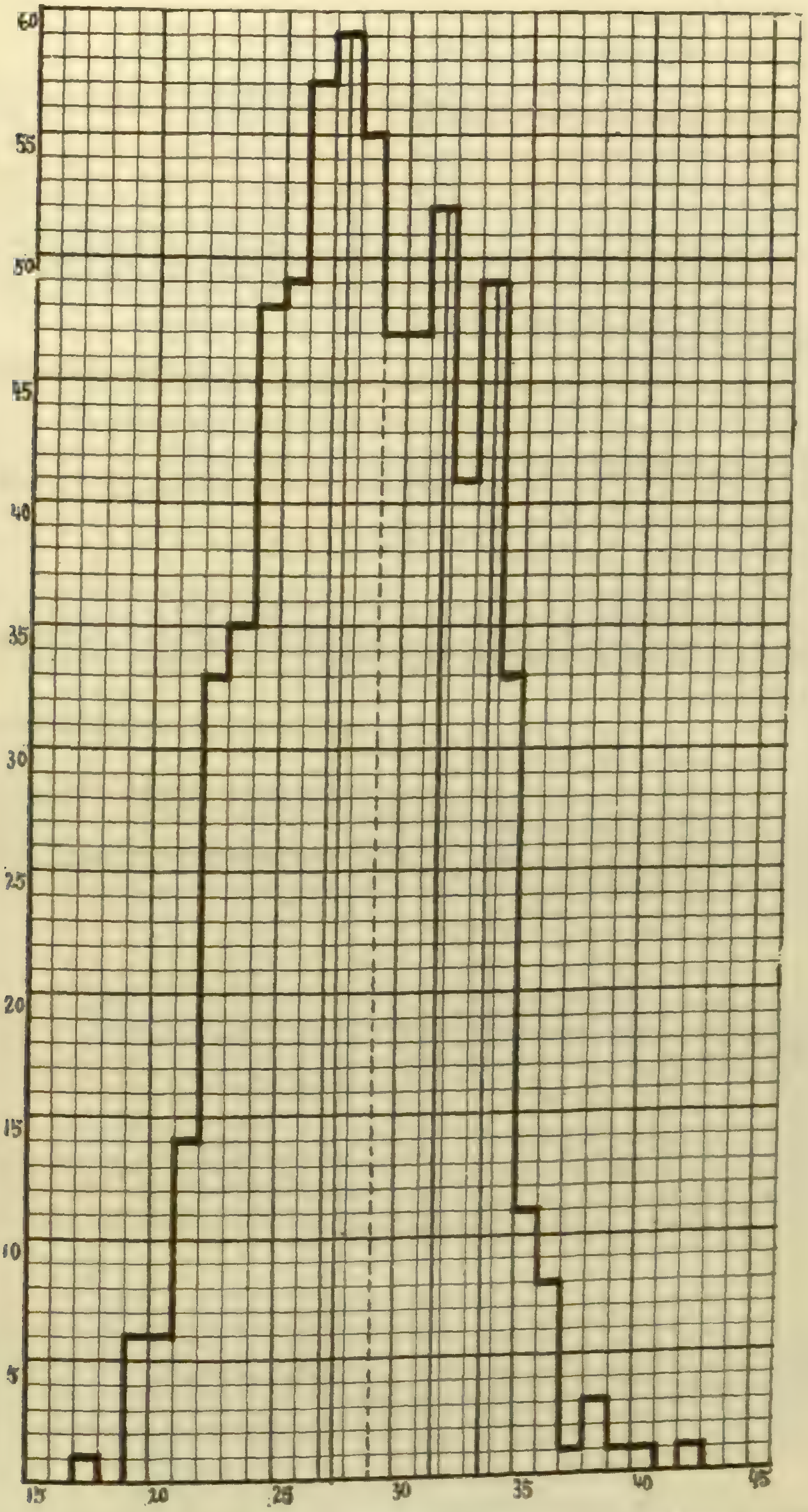


FIG. 17. — *Aster prenanthoides* Muhl. Ray curve of 658 heads. Mean = 28.037993 ± .107021; modes = 27, 31, 33; σ = 4.070071 ± .075675.

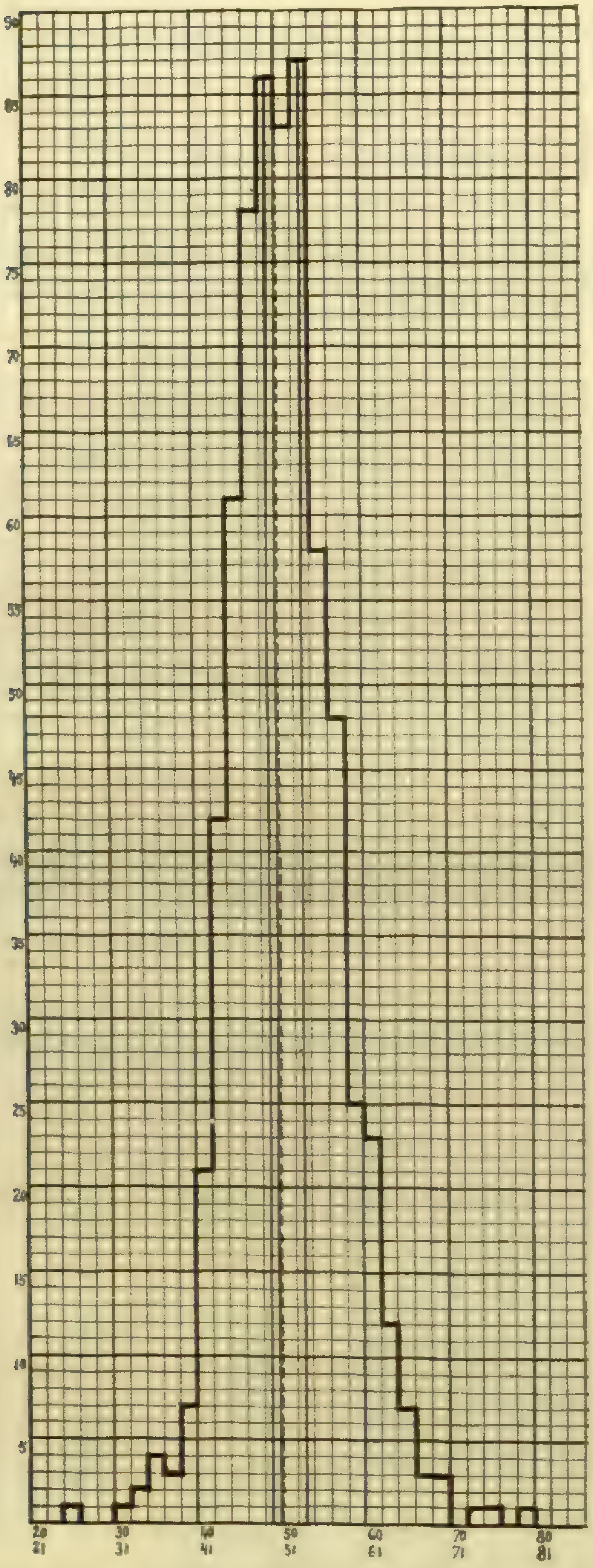


FIG. 18. — *Aster prenanthoides* Muhl. Disk curve of 658 heads. Classes doubled. Mean = 50.297872 ± .165889; modes 48–49, 52–53; $\sigma = 6.310315 \pm .117301$.

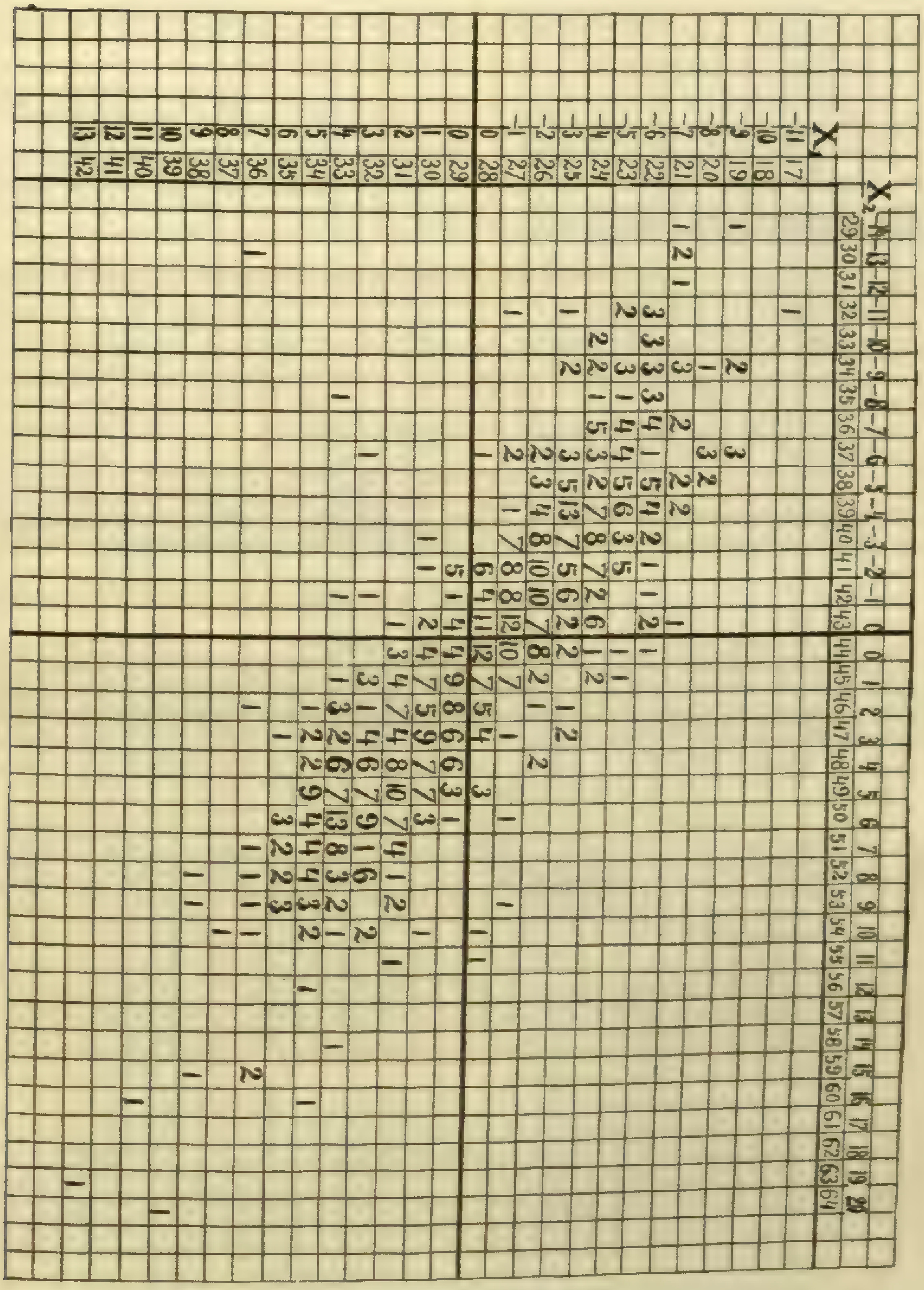


Fig. 19. — *Aster prenanthoides* Muhl. Correlation surface for 658 heads. Rays subject and bracts relative. $\rho = .776834 \pm .007820$.

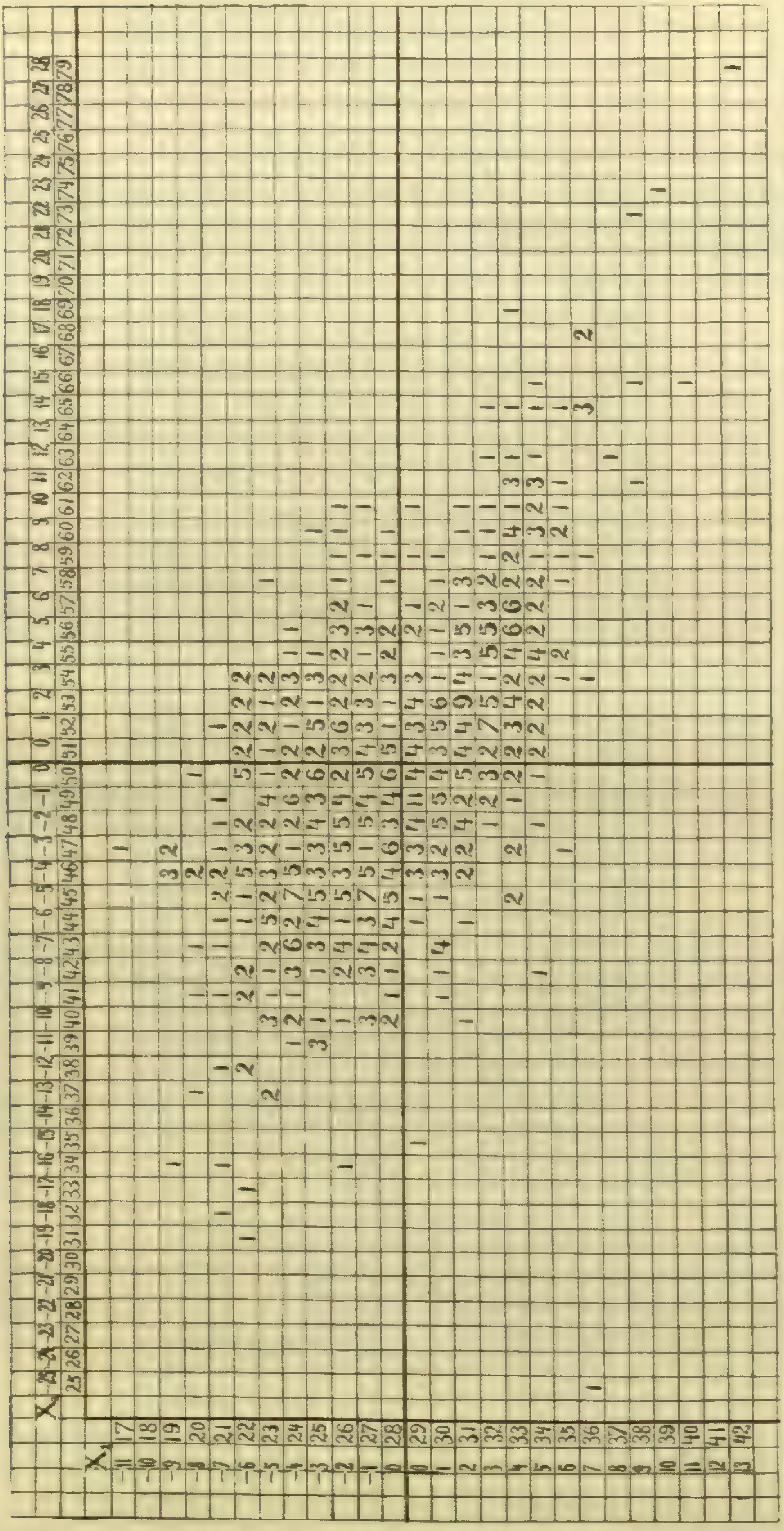


FIG. 20. — *Aster prenanthoides* Muhl. Correlation surface for 658 heads. Rays subject and disk florets relative. $\rho = .770316 \pm .008042$.

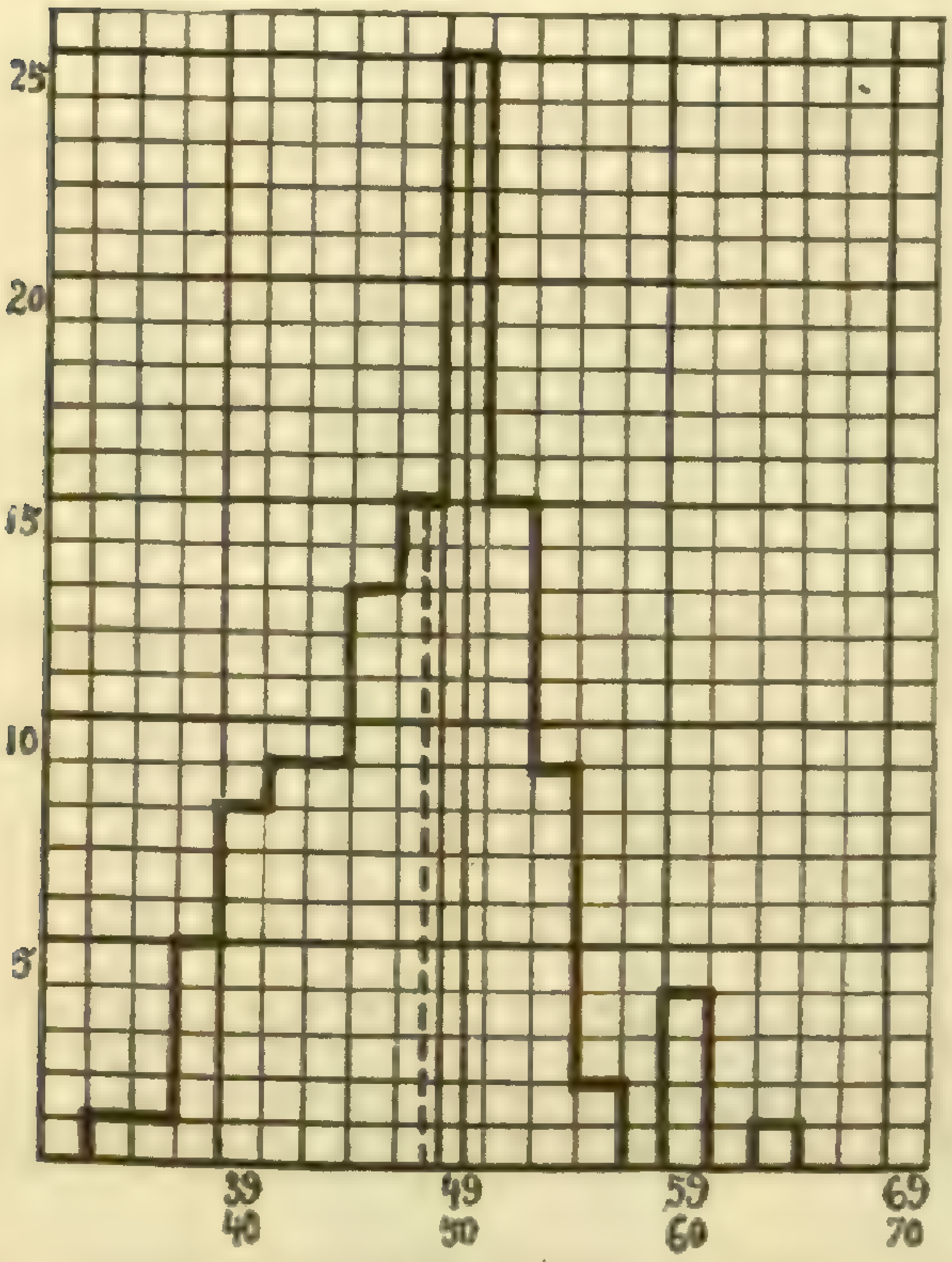


Fig. 21.

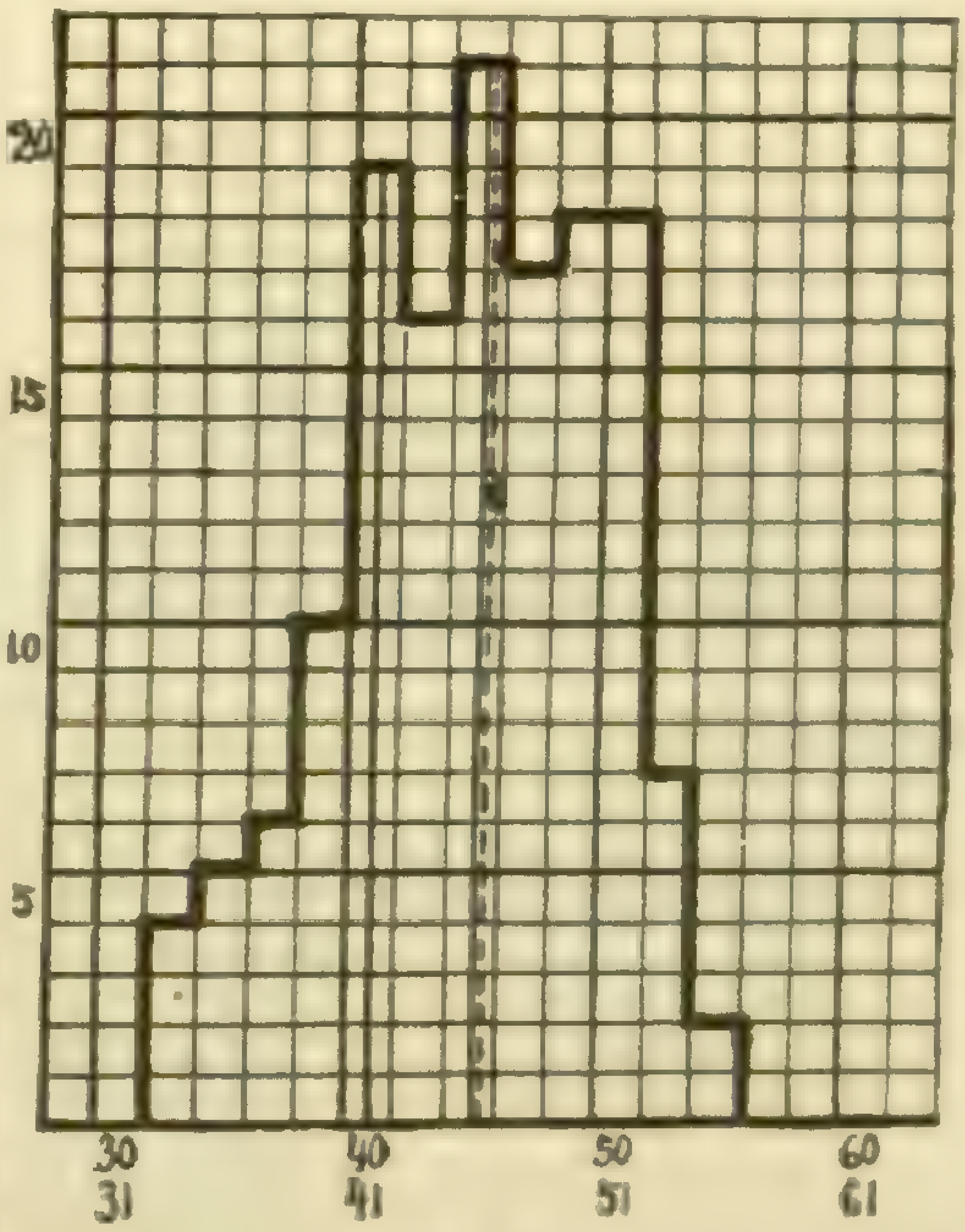


Fig. 22.

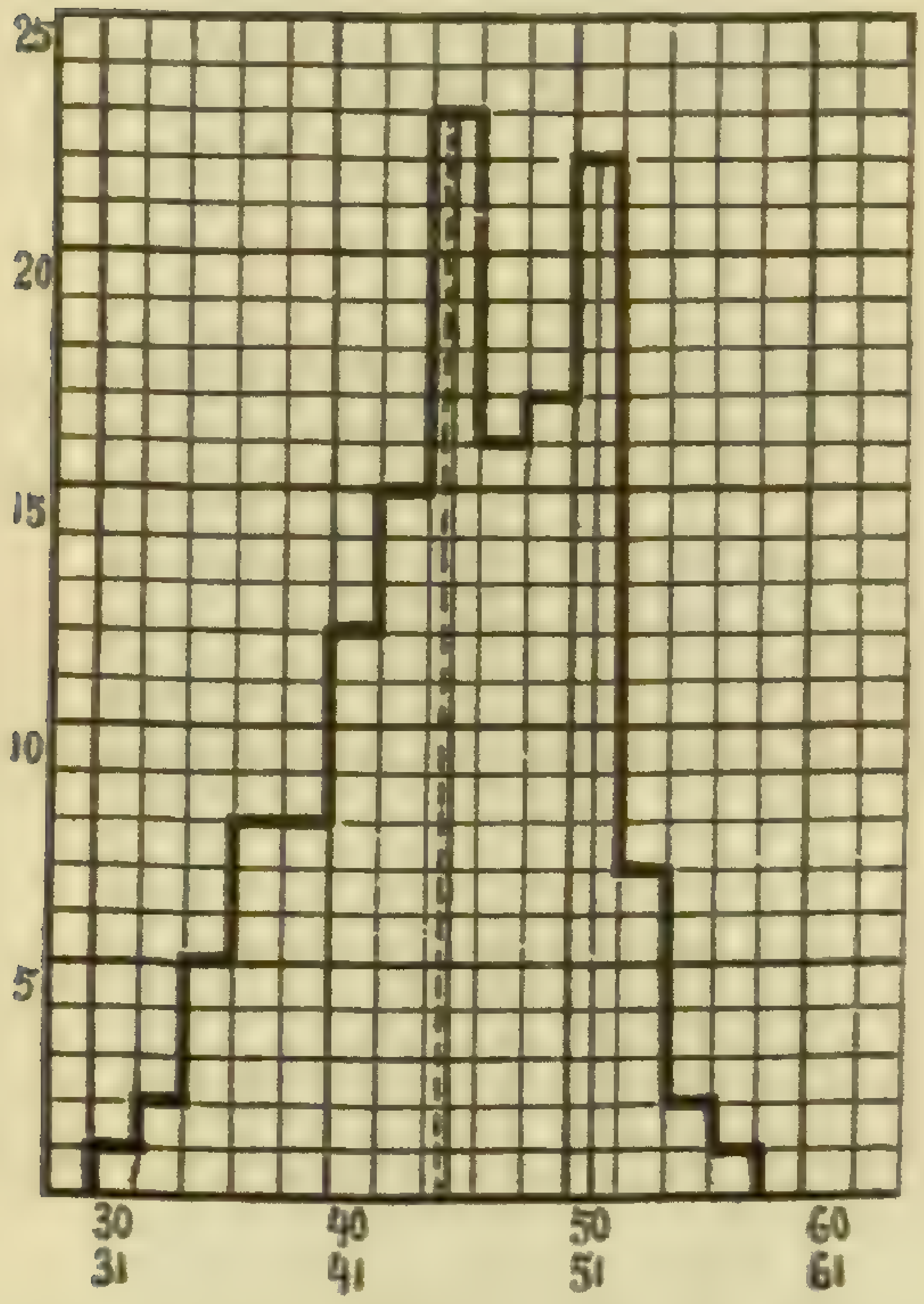


Fig. 23.

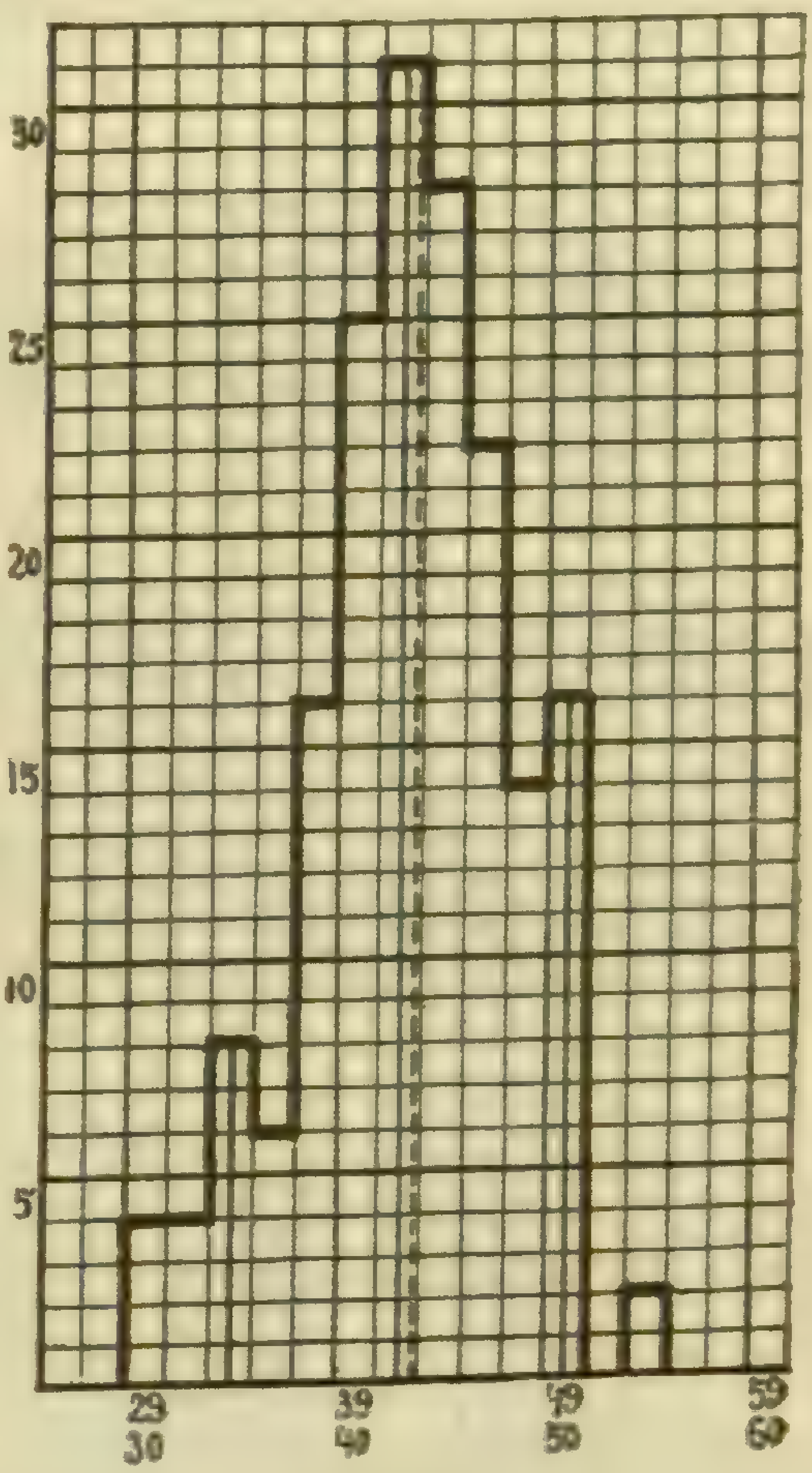


Fig. 24.

Fig. 21. — *Aster prenanthoides* Muhl. Bract curve of 117 heads collected September 27. Classes doubled. **Mean = 47.410256 ± .344540; mode = 49–50; σ = 5.524237 ± .243626.**

Fig. 22. — *Aster prenanthoides* Muhl. Bract curve of 143 heads collected on September 30. Classes doubled. **Mean = 44.342657 ± .290617; modes 40–41, 44–45, 48–51; σ = 5.152370 ± .205407.**

Fig. 23. — ***Aster prenanthoides*** **Muhl. Bract curve of 130 heads collected on October 4. Classes** doubled. Mean = 43.834532 ± 301.840; modes, 44–45, 50–51; σ = 5.275076 ± .213433.

Fig. 24. — *Aster prenanthoides* Muhl. Bract curve of 176 heads collected on October 8. Classes doubled. Mean = 41.920455 ± .248000; modes = 33–34, 41–42, 49–50; σ = 4.880626 ± .175784.

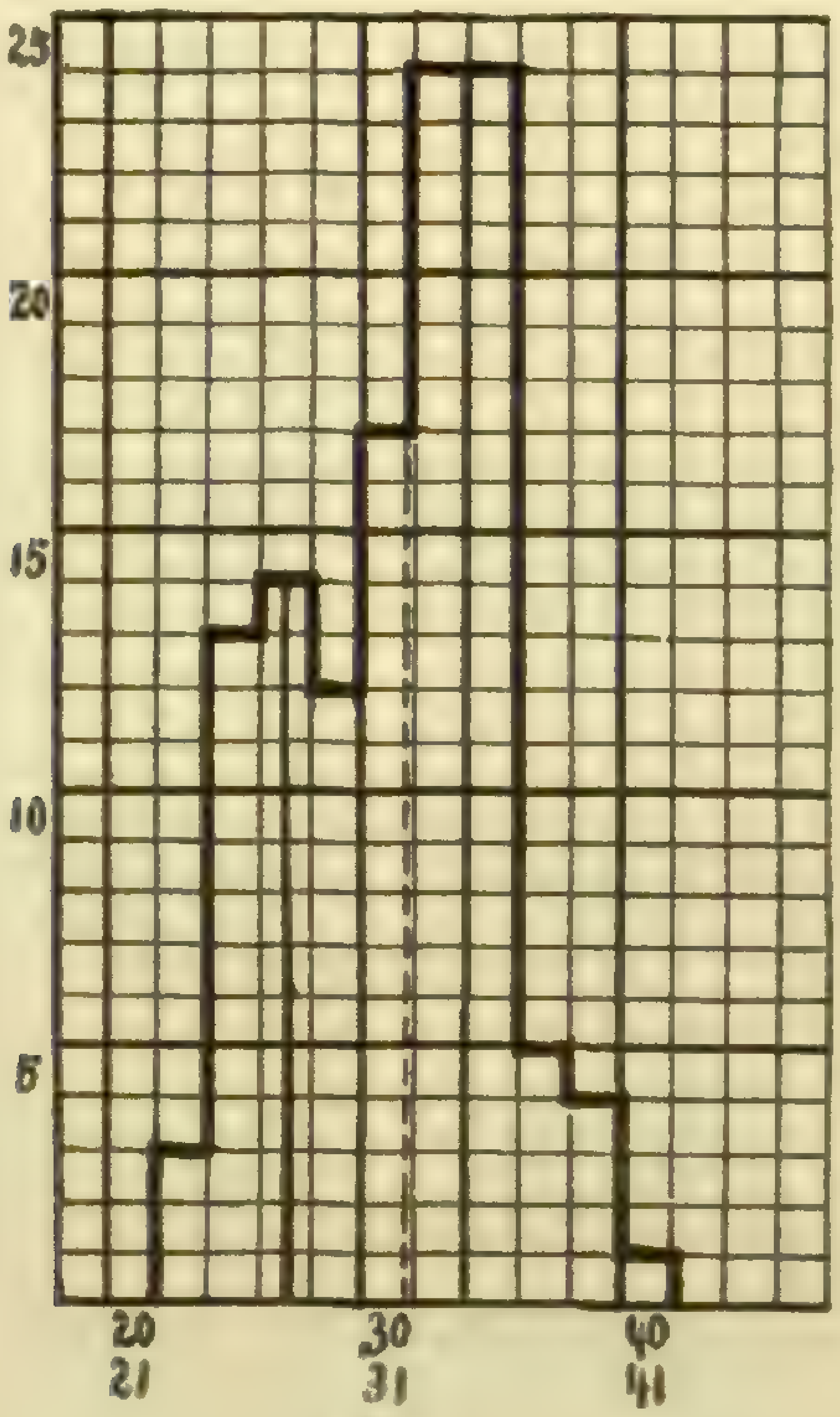


FIG. 25.

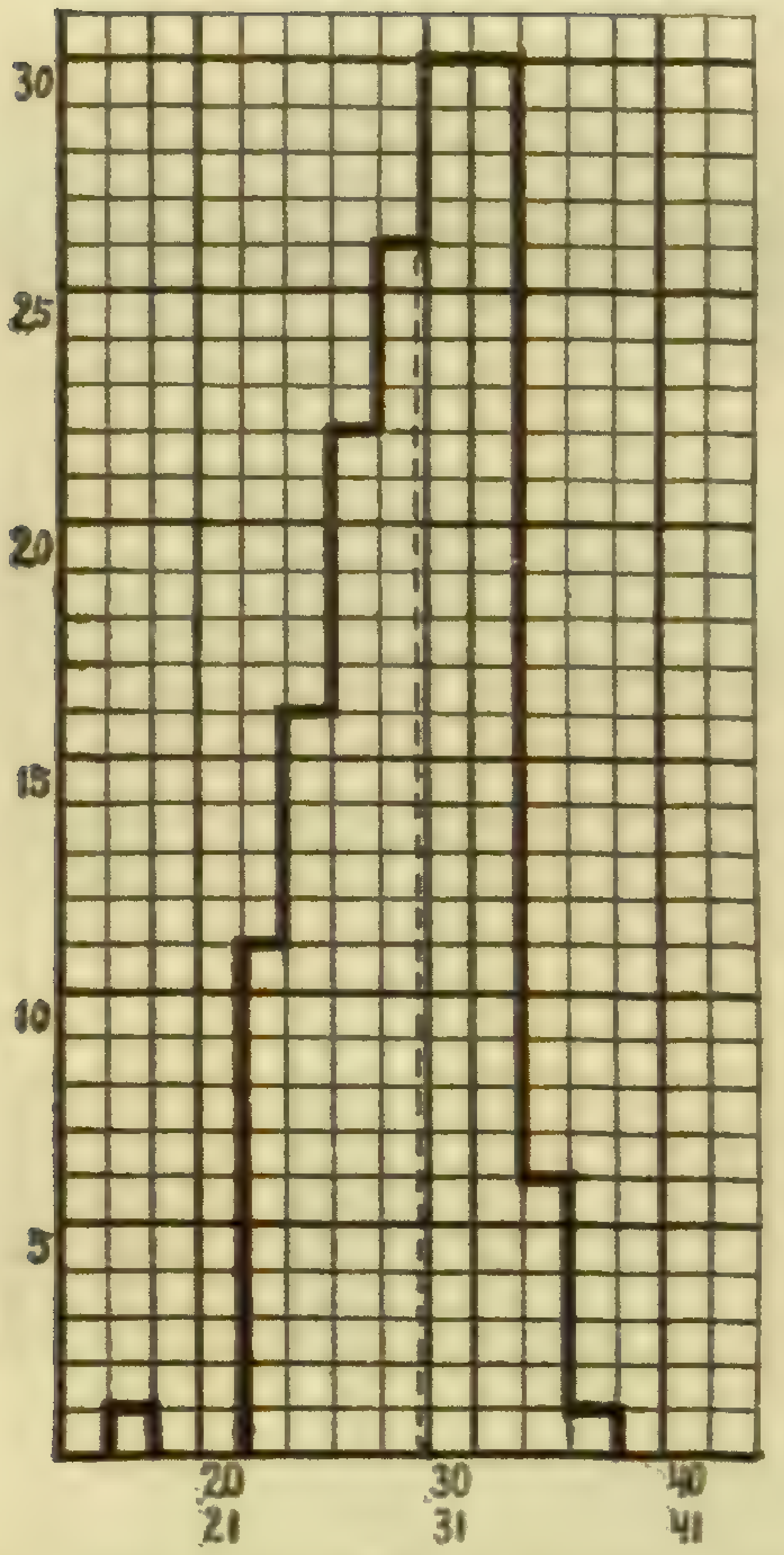


FIG. 26.

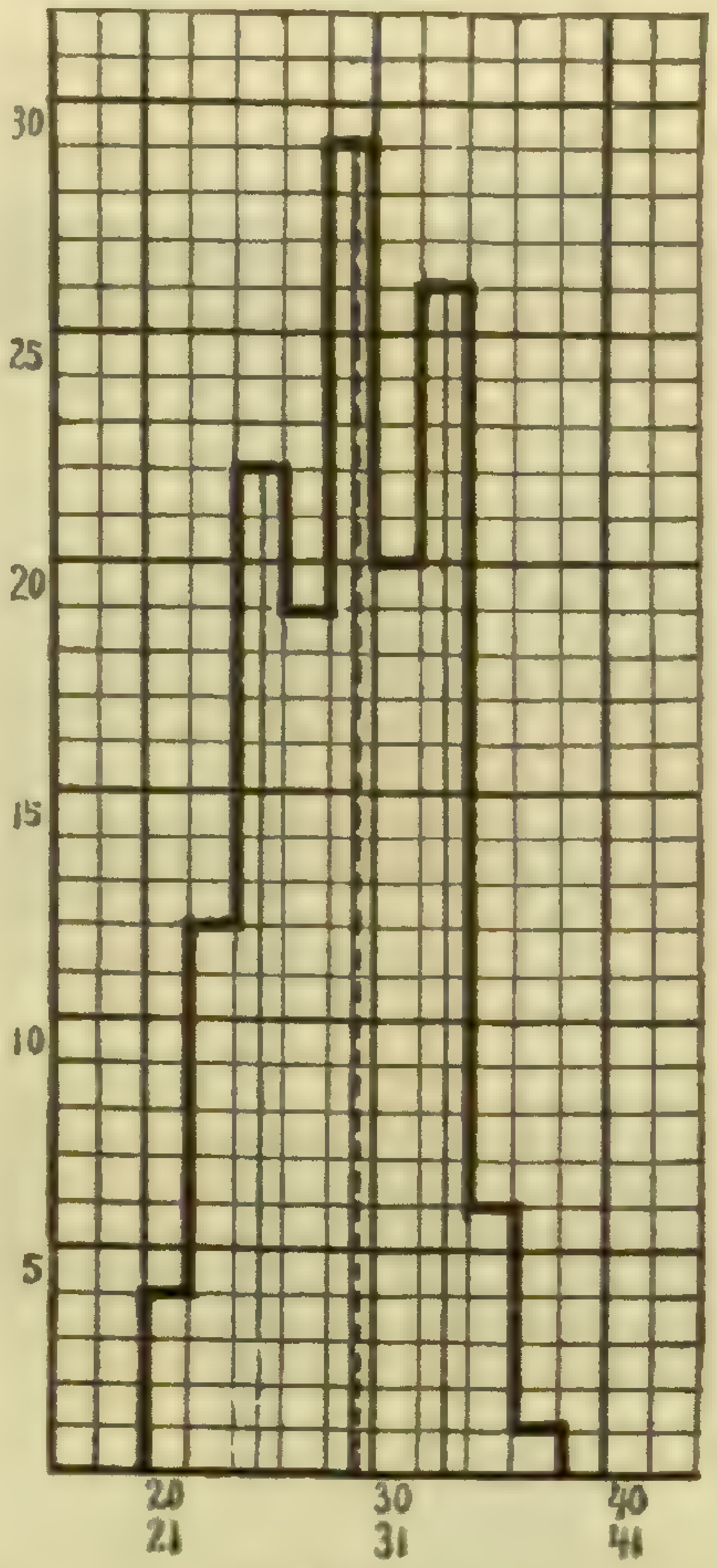
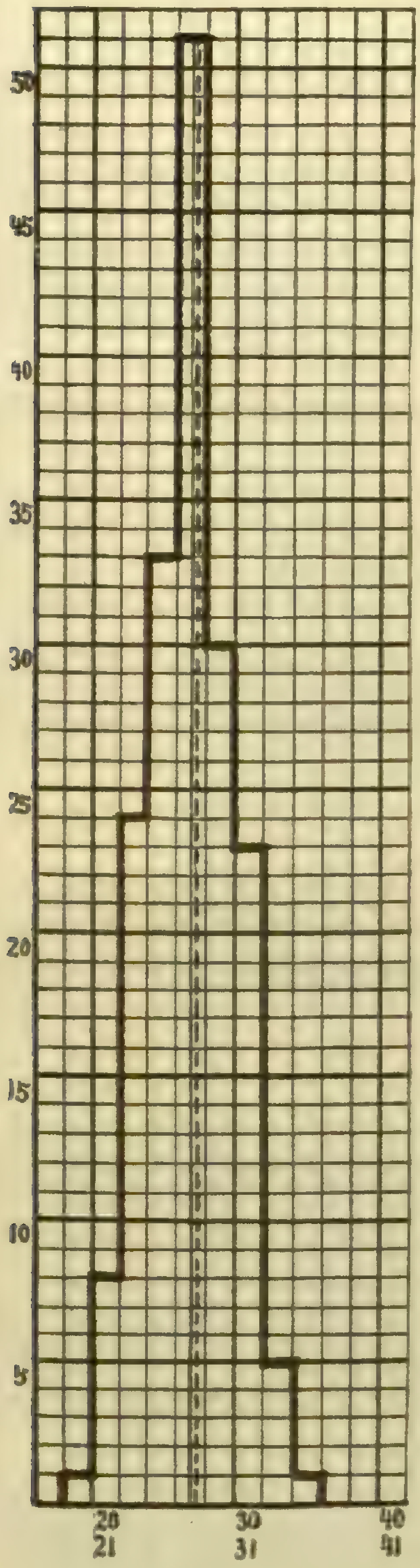


FIG. 27.

FIG. 25. — *Aster prenanthoides* Muhl. Ray curve of 117 heads collected on September 27. Classes doubled. Mean = 30.769230 ± .248547; mode = 26–27, 32–35; σ = 3.985839 ± .175749.

FIG. 26. — *Aster prenanthoides* Muhl. Ray curve of 143 heads collected on September 30. Classes doubled. Mean = 28.706293 ± .201316; mode = 30–33; σ = 3.569141 ± .142351.

FIG. 27. — *Aster prenanthoides* Muhl. Ray curve of 139 heads collected on October 4. Classes doubled. Mean = 28.251798 ± .200320; modes = 24–25, 28–29, 32–33; σ = 3.501476 ± .141641.



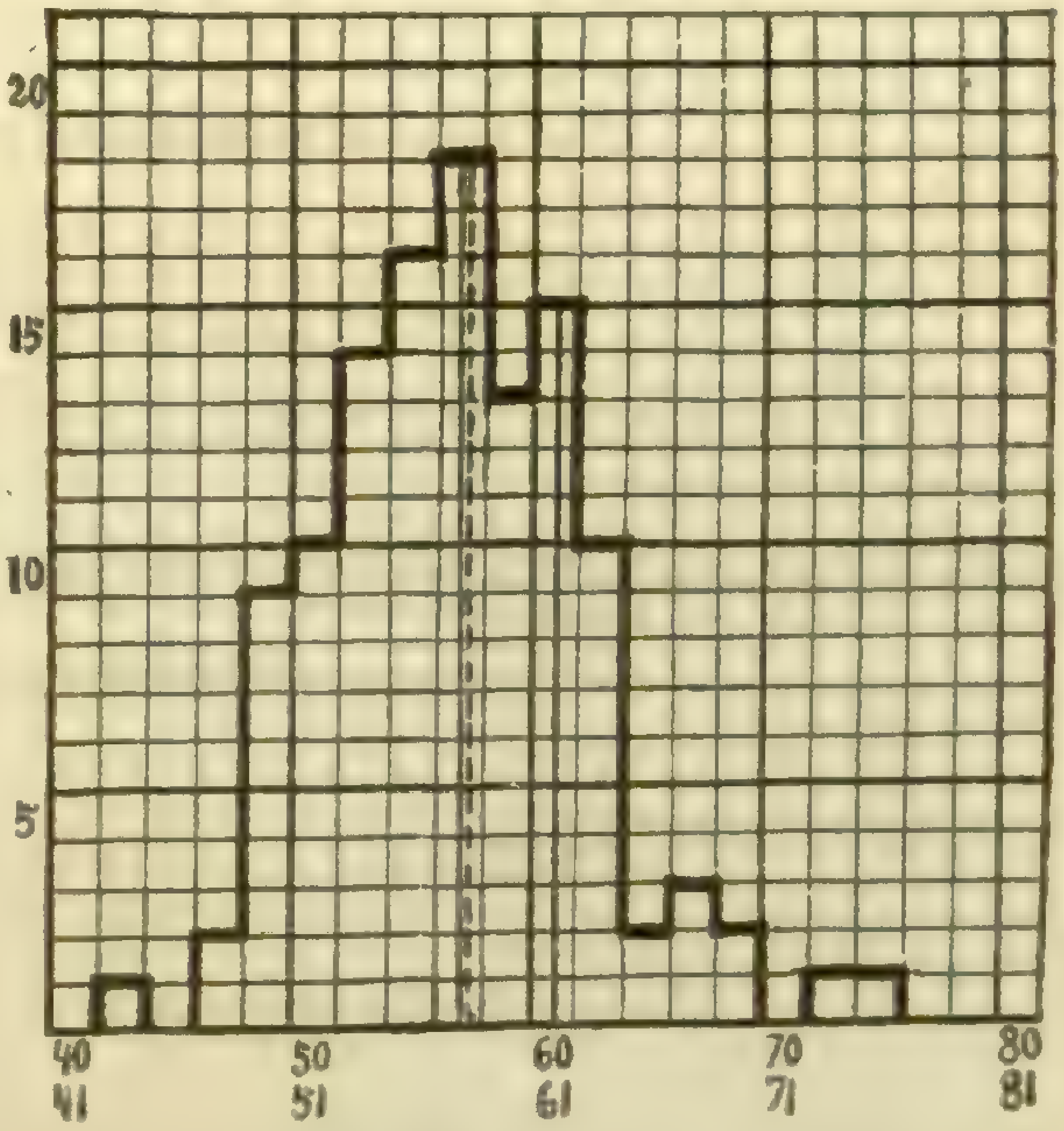


Fig. 29.

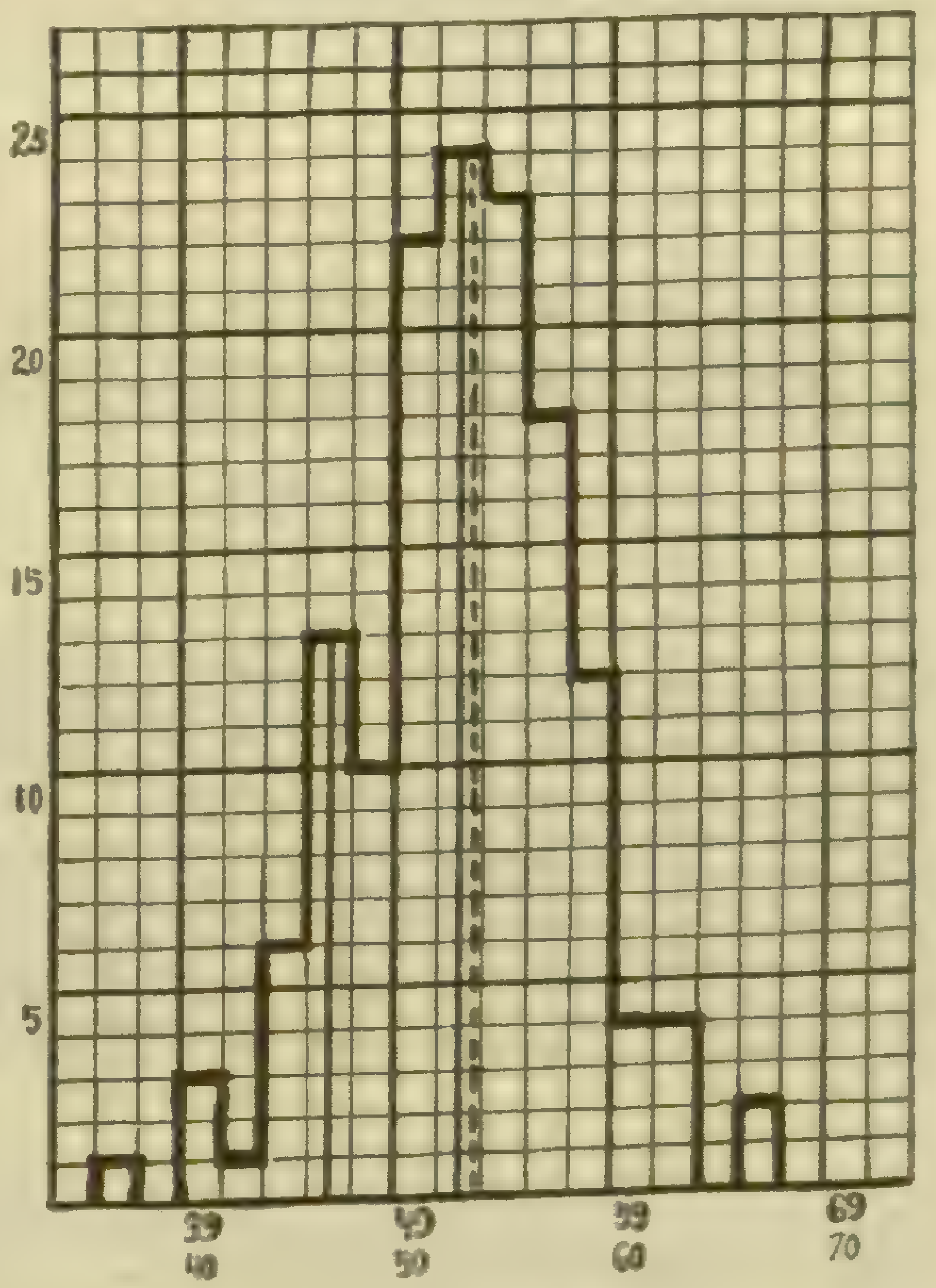


Fig. 28.

Fig. 30.

Fig. 28. — *Aster prenanthoides* Muhl. Ray curve of 176 heads collected on October 8. Classes doubled. Mean = $26.3352\dot{2}\dot{7} \pm .153066$; mode = 26–27; $\sigma = 3.010607 \pm .108234$.

Fig. 29. — *Aster prenanthoides* Muhl. Disk curve of 117 heads collected on September 27. Classes doubled. Mean = $56.\dot{4}2735\dot{6} \pm .248547$; modes = 56–57, 60–61; $\sigma = 3.985839 \pm .175749$.

Fig. 30. *Aster prenanthoides* Muhl. Disk curve of 143 heads collected on September 30. Classes doubled. Mean = $51.\dot{7}1328\dot{6} \pm .281728$; modes = 45–46, 51–52; $\sigma = 4.994779 \pm .199211$.

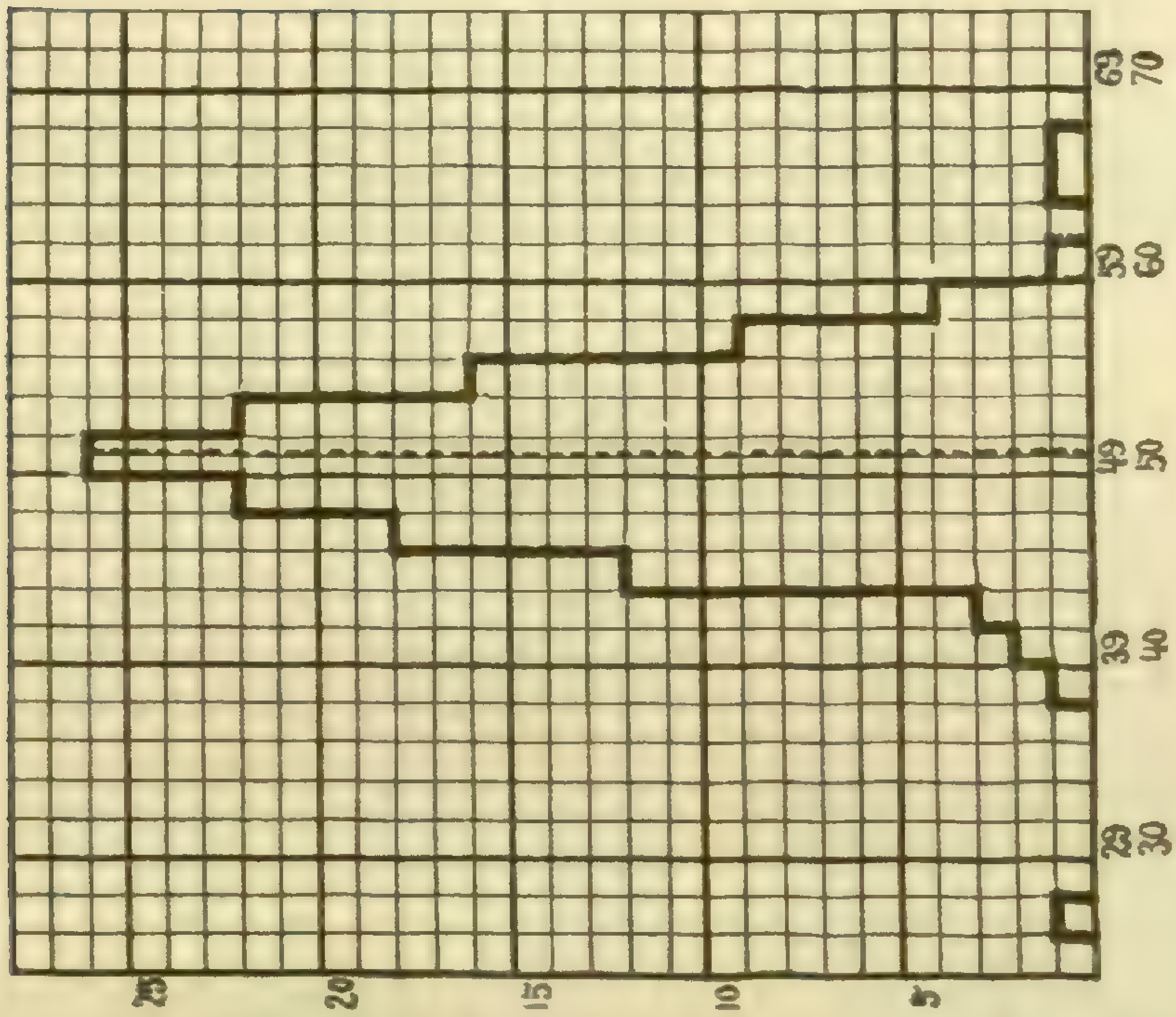


FIG. 31. — *Aster prenanthoides* Muhl. Disk curve of 139 heads collected on October 4. Classes doubled. Mean = 49.158273 ± .279452 ; mode = 49–50 ; σ = 4.884653 ± .197602.

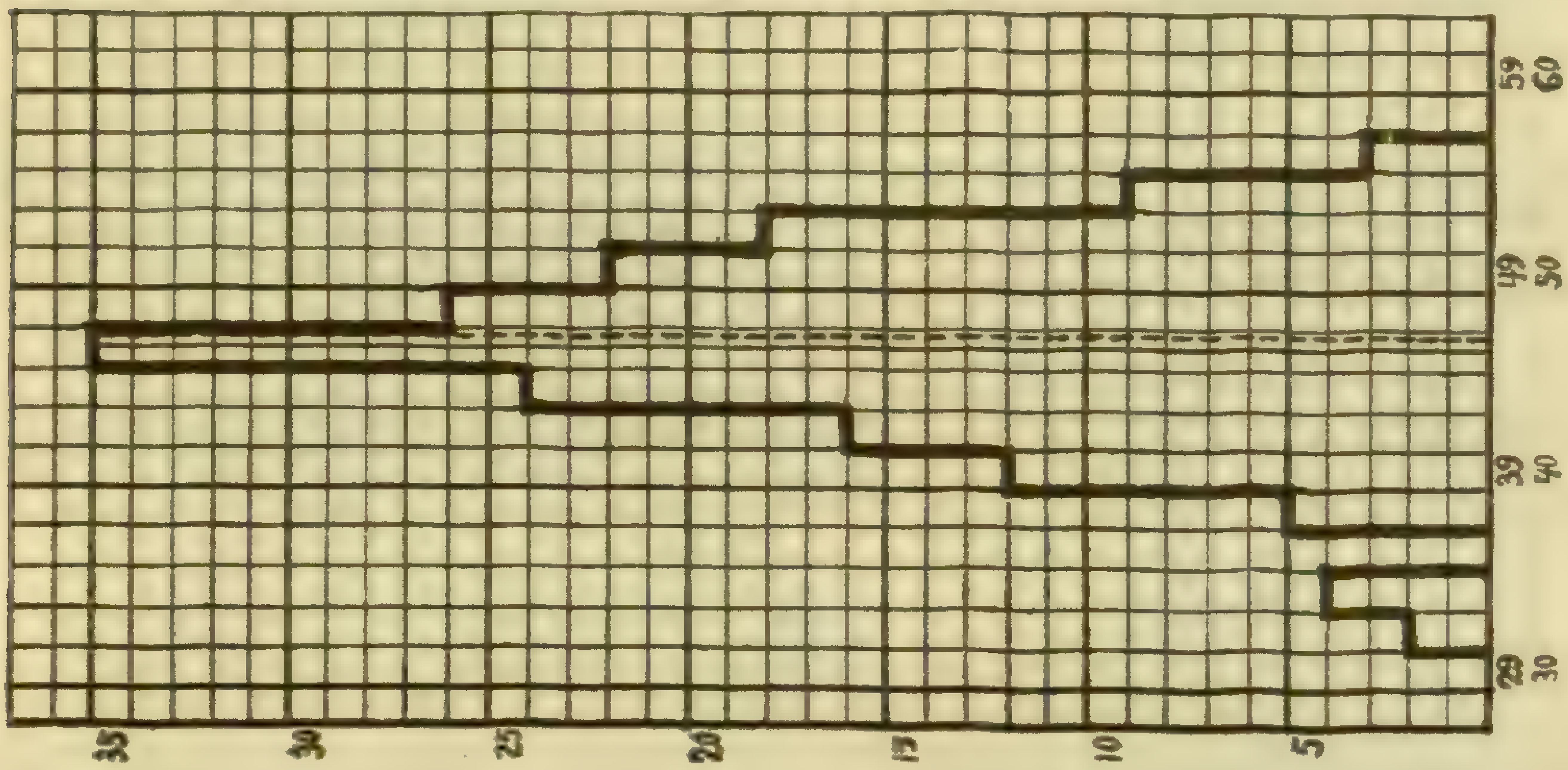


FIG. 32. — *Aster prenanthoides* Muhl. Disk curve of 176 heads collected on October 8. Classes doubled. Mean = 45.778409 ± .242280 ; mode = 45–46 ; σ = 4.777197 ± .171318.

	X_2	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
X_1		33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64
-8	22			1																													
-7	23							2																									
-6	24	1					1	1	1																								
-5	25					1	2	2	1	1	2																						
-4	26					1				2	1	2	1				1																
-3	27								1	1			2	1								1											
-2	28											1	2	1	1			1						1									
-1	29									1		1		2	1																		
0	30													1	1	1		1	1														
0	31													1	2	1	4	3		1													
1	32															2	3	3			2												
2	33										1				1		2	4	2	1	2	1											
3	34														1		1	4	3	2	3		2		1				1				
4	35																		3		2	1											
5	36																			1		1	1					1					
6	37																						1										
7	38																				1	1						1					
8	39																																1
9	40																												1				

FIG. 33. — *Aster prenanthoides* Muhl. Correlation surface for 117 heads collected on September 27. Rays subject and bracts relative. $\rho = .855944 \pm .012237$.

	X_2	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	0	1	2	3	4	5	6	7	8	9
X_1		32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
-11	17	1																						
-10	18																							
-9	19																							
-8	20																							
-7	21																							
-6	22	1	1		1		1	1	1															
-5	23				1		1	1	2															
-4	24			2		2				2	1	1	2											
-3	25	1						1	2	1				1										
-2	26						1		2	6	2	2	1	1	1									
-1	27										2	1	1	1										
0	28										2	1	3	4	3		2							
0	29										2		2	1	1		2	2		1				
1	30									1			1		3	2	3	3	1					
2	31													3	1	2	1	3	2	1	2		1	
3	32											1			1	1		1	2	3	1	2		1
4	33				1											1	1	2		5	4	1	1	1
5	34																2		2				1	
6	35																				1			
7	36																					1		

FIG. 34. — *Aster prenanthoides* Muhl. Correlation surface for 143 heads collected on September 30. Rays subject and bracts relative. $\rho = .833702 \pm .012701$.

	X_2	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	0	1	2	3	4	5	6	7	8	9	10	11
X_1		30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55
-8	20					1																					
-7	21							1		1	1																
-6	22							2																			
-5	23			2		1		2	1	2		1				1											
-4	24				1		1	2	1			1	3	1	1												
-3	25					2			2		4	1		1	1												
-2	26											1		2	1												
-1	27										1	2		3	5	2	1					1					
0	28								1				2	1	3	3	2	2	1		1						
0	29												1	1		2	2	2	1	2	2						
1	30														1	2	1		2		1	1					
2	31														1		1	2	2	1	1	2		1			1
3	32																2		2	2	2	4		2		1	
4	33																	1	1	2	1	5	1				
5	34																				1		1	1	1		
6	35																		1				1				
7	36	1																									

FIG. 35. — *Aster prenanthoides* Muhl. Correlation surface for 139 heads collected on October 4. Rays subject and bracts relative. $\rho = .798642 \pm .015133$.

	X_2	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	0	1	2	3	4	5	6	7	8	9	10	11	12
X_1		29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
-7	19	1																									
-6	20									1	1																
-5	21	1	2	1			2																				
-4	22				2	2	2	1	2		4	1		1													
-3	23						2		2		1	1	1	2													
-2	24								1	2	1	4	4	2		2	1	1									
-1	25										2	3	4	2	1		1			2							
0	26										2	2	1	6	3	2	3	1									
0	27				1					1			4	5	3	6	5	5		1							
1	28													2	2	4	2	1	1	1		1					1
2	29													1		1		2	5	3	2	1					
3	30													1			1	1	2	1	4	4	1				
4	31																	1	1			3	2			1	
5	32									1													2				
6	33																	1				1					
7	34																					1					

FIG. 36. — *Aster prenanthoides* Muhl. Correlation surface for 176 heads collected on October 8. Rays subject and bracts relative. $\rho = .803092 \pm .013443$.

	X_2	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
X_1		42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74
-8	22							1																										
-7	23													1				1																
-6	24					1								2		1																		
-5	25								1	2		1	1	2	1					1														
-4	26							1			2		1		1		1		1		1													
-3	27								1			1				2			1		1													
-2	28								1	1	1					1		1	1	1														
-1	29							1	1							1			1		1													
0	30									1			2	1					1															
0	31						1	2		1			2	2		1	1	1			1													
1	32										1	1	1		2	1	1	1	1	1														
2	33												3		1	3	1		1	2		2	1											
3	34	1									1		1		1	2	2	1		2	2	3	1			1								
4	35													1	1					2		1			1									
5	36																		1						1			2						
6	37																						1											
7	38																					1				1							1	
8	39																																	1
9	40																									1								

Fig. 37.—*Aster prenanthoides* Muhl. Correlation surface for 117 heads collected on September 27. Rays subject and disk florets relative. $\rho = .573693 \pm .033347$.

	X_2	-16	-15	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	0	1	2	3	4	5	6	7	8	9	10	11	12	13
X_1		35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65
-11	17													1																		
-10	18																															
-9	19																															
-8	20																															
-7	21																															
-6	22														1			1	2	1	1											
-5	23												1		2		1				1											
-4	24									1		1	2		1	1	2		1	1												
-3	25												1	1				1	3													
-2	26								1			1	2		1		1		2	1	2	1	2	1			1					
-1	27									1							1			2	1			1								
0	28						2				2	1	1			1	1	2			2	2	1									
0	29	1													1	3	1	1	2				1	1								
1	30									2		1	1			1	2	2	2	1				1	1							
2	31						1						1		2			1	1	3	1	1	3		1		1					
3	32															1	2		1	1		1	2	2	1			1				1
4	33															1	2		2		1	2	1	2	1		2	1	1			1
5	34																1			1	2	1										
6	35																											1				
7	36																				1											

Fig. 38.—*Aster prenanthoides* Muhl. Correlation surface for 143 heads collected on September 30. Rays subject and disk florets relative. $\rho = .358909 \pm .042145$.

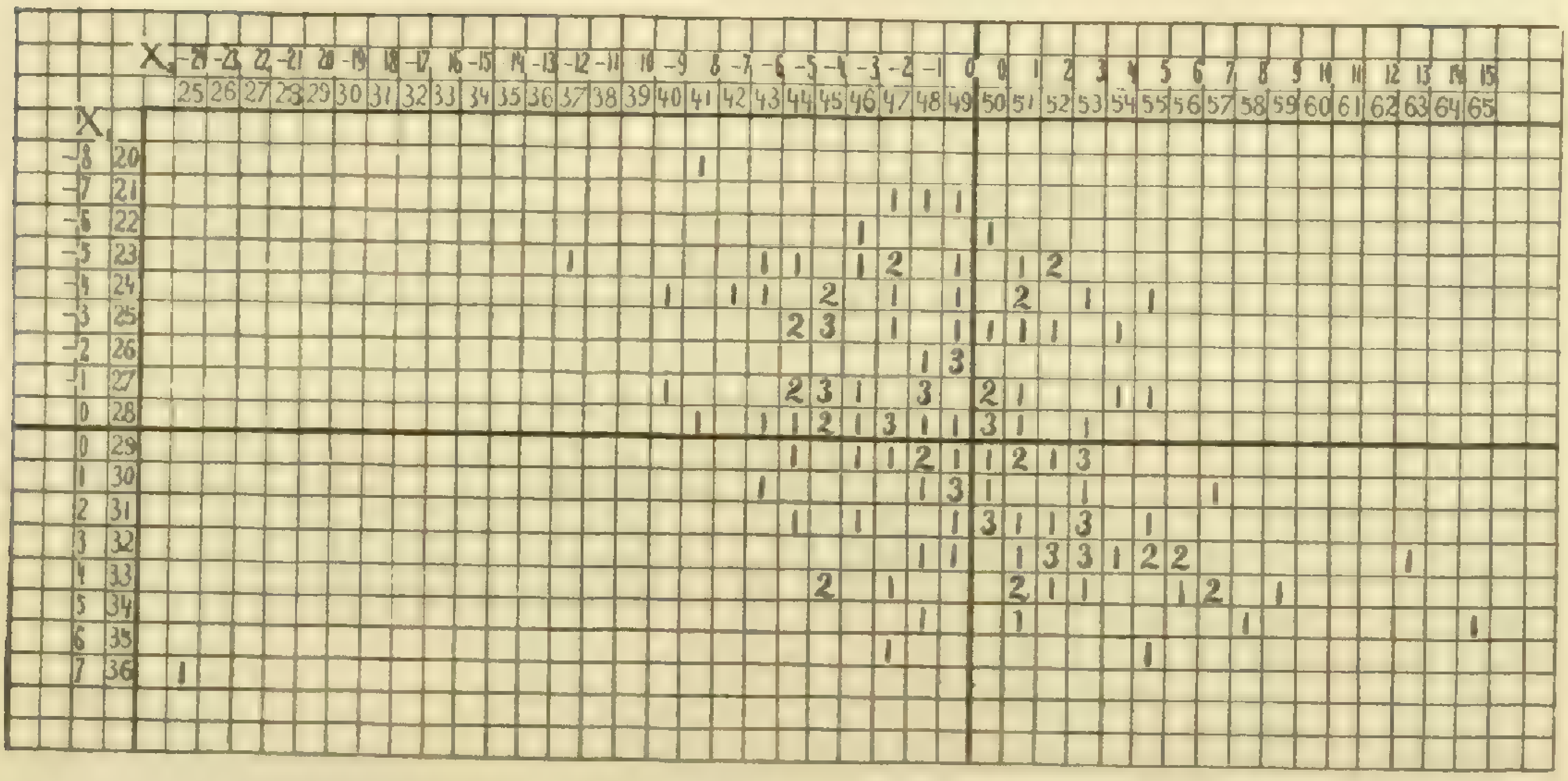


FIG. 39. — *Aster prenanthoides* Muhl. Correlation surface for 139 heads collected on October 4. Rays subject and disk florets relative. $\rho = .353102 \pm .043050$.

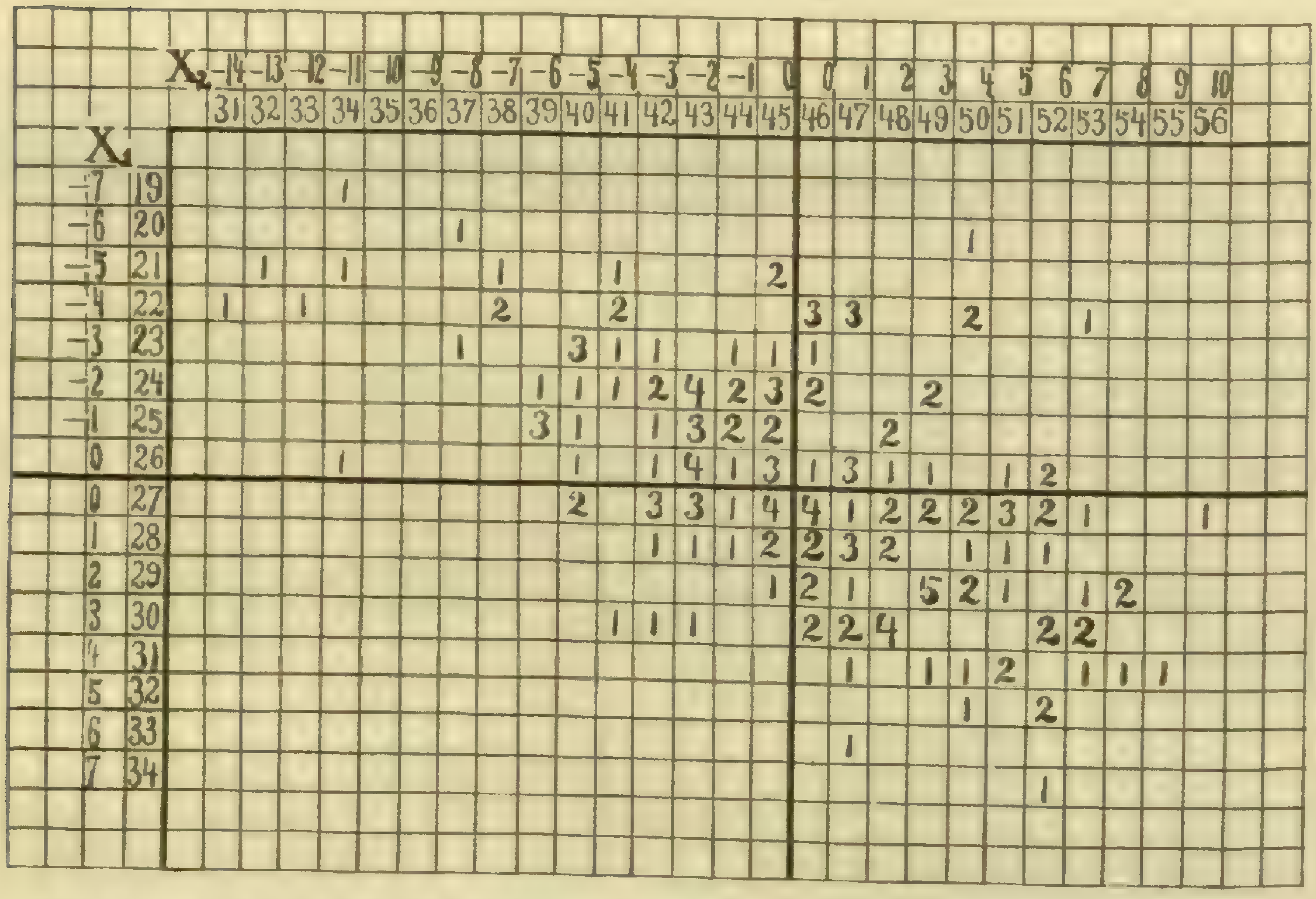


FIG. 40. — *Aster prenanthoides* Muhl. Correlation surface for 176 heads collected on October 8. Rays subject and disk florets relative. $\rho = .545208 \pm .012157$.

Table F. — Constants of Rays of Four Pickings of *Aster prenanthoides* Muhl.

	117 Capitula, collected September 27.	143 Capitula, collected September 30.	139 Capitula, collected October 4.	176 Capitula, collected October 8.
Mean	30.769230	28.706293	28.251798	26.335227
Mode	26–27 32–35	30–33	24–25 28–29 32–33	26–27
A. D.	3.353057	2.991736	3.012680	2.452608
σ	3.985839	3.569141	3.501476	3.010607
P. E. A. D.	± 2.688448	± 2.407386	± 2.361745	± 2.030654
P. E. M.	± .248547	± .201316	± .200320	± .153066
P. E. σ	± .175749	± .142351	± .141641	± .108234
C. V.	12.953945	12.4333306	12.393818	11.431865

The variations of the disk in the four collections may be compared in the following table.

Table G. — Constants of Disk Florets of Four Pickings of *Aster prenanthoides* Muhl.

	117 Capitula, collected September 27.	143 Capitula, collected September 30.	139 Capitula, collected October 4.	176 Capitula, collected October 8.
Mean	56.427350	51.713286	49.158273	45.778409
Mode	56–57 60–61	45–46 51–52	49–50	45–46
A. D.	3.353057	3.925179	3.619481	3.750581
σ	3.985839	4.994779	4.884653	4.777197
P. E. A. D.	± 2.688448	± 3.368978	± 3.294698	± 3.222219
P. E. M.	± .248547	± .281728	± .279452	± .242280
P. E. σ	± .175749	± .199211	± .197602	± .171318
C. V.	12.953947	9.661212	9.936585	10.435481

4. *Correlations.* The correlation surfaces for rays and bracts, in the four collections, are shown in Figs. 33, 34, 35, and 36, and for rays and disks in Figs. 37, 38, 39, and 40. The coefficients of correlation are arranged for comparison in the following table.

Table H. — Correlation of Rays and Bracts and of Rays and Disk Florets in Four Pickings of Aster prenanthoides Muhl.

		117 Capitula, collected September 27.	143 Capitula, collected September 30.	139 Capitula, collected October 4.	176 Capitula, collected October 8.
Rays and Bracts	ρ P. E.$_\rho$	.855944 ± .012237	.833702 ± .012701	.798642 ± .015133	.803092 ± .013443
Rays and Disk	ρ P. E.$_\rho$	.573693 ± .033347	.358909 ± .042145	.353102 ± .043050	.545208 ± .012157

Inspection of this table shows that the highest degree of correlation between the parts was found at the beginning of the flowering season, and that there was a constant fall for both bracts and disk florets until near the end of the season, when the coefficient of correlation again slightly increased. The increase in the coefficient of correlation between rays and bracts in the last collection was less than the "probable error" of the determination, but that between the rays and disk florets had increased until its value was only .0284 less than in the first collection.

V. Discussion of Results.

The species which have been chosen for this study are quite distinct, and although *Aster puniceus* L. and *Aster prenanthoides* Muhl. belong to the same division of the genus, *Aster novæ-angliæ* L. is more distant from these, and *Aster shortii* Hook. belongs to a division which is separated in a marked degree from the others. Considering this wide separation, it is rather remarkable that there should be so close an agreement in the number of bracts in the four species. The lower limit of range varies from 28 to 30, the upper limit from 49 to 64, and the means from 36.8 to 44.5. With the bracts so nearly constant, there is a range in the mean number of rays from 14 in *A. shortii* Hook. to 42.8 in *A. novæ-angliæ* L., and yet the degree of correlation between rays and bracts is high in all

the species studied, the coefficient of correlation between them ranging from .549 + to .802 +.

The fact that the correlation between bracts and rays was found to be greater in every case than that between rays and disk florets gave rise to the question, What is the relation existing between bracts and rays? After a careful study of the position of the rays with reference to the bracts, it seems that the rays are axillary to the bracts, and that typically a nearly constant proportion of the bracts in the capitula of a species produce rays in their axils, the rest remaining empty. The material studied showed the mean number of empty bracts in each head to be as follows: *A. shortii* Hook. 22.8, *A. prenanthoides* Muhl. 16, *A. puniceus* L. 7.9, and *A. novæ-angliæ* L. 1.2.

The number of species here studied is too small to permit the derivation of laws covering so large a genus as Aster, but in these four species the degree of imbrication of the involucral bracts was apparently in direct proportion to the number of empty bracts. In *A. shortii* Hook., which has so many empty bracts, the scars left by their removal occupies the convex surface of an inverted cone, the base of which served as the receptacle for the comparatively small number of florets; while in *A. novæ-angliæ* L., where almost every bract has its ray, the scars formed a narrow ring about the broad receptacle. In the former there was considerable difference in form and size between the minute outer bracts and the inner ray-bearing bracts, while in the latter all the bracts were very much alike in size and form. In a number of capitula of *A. novæ-angliæ* L. there were found more rays than bracts. Some of the more marked cases of this kind were examined and the rays distinctly seen to form a scattering second row within the full outer row which is typical of Aster; in other words, some of the disk florets developed ligulate corollas.

The suggestion of several writers that statistical methods will prove valuable in taxonomic work is not sustained by the results set forth in this paper. It is obviously impossible to describe a species by means of the variability constants in such manner as to allow the classification of individuals which

possess but single variates of the kind used in determining those constants.

The above-stated results in *A. puniceus* L. make obvious the same truth in regard to species such as those of Compositæ, in which the individual may have a sufficient number of variates to give a good frequency polygon and constants with small "probable errors." The wide differences between the three individuals of *A. puniceus* L. show that the variability "constants" for individuals are only in a measure less variable than the characters upon which they depend.

The study of the successive collections shows another phase of the subject of variability which would materially affect the value of statistical methods in taxonomic questions relative to the Compositæ. In these successive collections there was a continuous decline in the numbers of bracts, rays, and disk florets, and a continuous change in the position of means and modes. These results could have been in no way dependent upon unnatural conditions induced by the clipping of the heads, since even the last to bloom were well-developed buds at the time the first collection was made; and had there been a change brought about in this way, it must have been in the opposite direction, since it is a well-known fact that the removal of the earlier flowers gives increased vigor to later ones.

This continuous change of means and modes during the blooming season is suggested as a possible explanation of Lucas's ('98) results upon *Chrysanthemum leucanthemum* L., other than that of difference of locality. He found that there was a marked difference between the results obtained from material collected at Yarmouth and Grand Pic, Nova Scotia, and that collected later at Milton and Cambridge, Mass. The earlier material from Nova Scotia showed the mean on 24.389 and the principal mode on 22, while the later collection from Massachusetts had the mean on 21.61 and the mode on 21.

Ludwig ('00), in commenting on these results, attributes their deviation from his own observations to the scantiness of Lucas's material, while Lucas implies, though he does not say it definitely, that the difference is a local one. In the light of my observations on *A. prenanthoides* Muhl. it seems a fair

question whether the difference may not have been in part due to the difference in the time at which the collections were made.[1]

Although the material of *A. prenanthoides* Muhl., upon which this study of successive collections is based, is even less than that used by Lucas, the constancy of the fall in numbers of all the parts can leave little doubt as to the essential correctness of my results. As a few days makes a marked difference in the condition of these variable characters, different seasons may likewise be found to give different results upon material collected from the same individuals.

As the capitula which terminate the axes in the Asters are the first to bloom, my observations on the decline in the number of parts in the heads of *A. prenanthoides* Muhl. bear a close relation to those of Burkill ('95) on *Caltha palustris* L., *Ranunculus arvensis* L., *R. bulbosus* L., *R. Ficaria*, and *Thalictrum flavum*, where he arrives at the conclusion that the "position of the flower on the axis affects the sexual organs, if they vary."[2]

Ludwig ('00) remarks concerning this, that "weil die Zahl der Carpelle, ebenso wie die der anderen Blütentheile und der Blütenzahlen in der Inflorescenz von der Stellung an der Axe abhängig ist, wird man Mischcurven erhalten, wenn man die Zählungen auf sämmtliche Organe der einzelnen Pflanze, nicht auf einzelne gleichwerthige Organe der verschiedenen Pflanzen

[1] Since this was written, W. L. Tower has investigated *Chrysanthemum leucanthemum* L. with reference to this point, and found that there is a continuous decrease in the values of mean and modes from the beginning to the end of the flowering season. His results will appear in *Biometrika*, vol. 1, no. 2.

[2] In his studies on the plants named, and others in which the number of stamens and carpels vary, he finds that "the earlier formed flowers on the plant carry more stamens or more carpels, or perhaps more of both organs, than those formed later in the season," and that "flowers holding any position of advantage on an inflorescence, *i.e.*, terminal on a cyme, or at the base of a raceme, even if not maturing earliest, carry more stamens or carpels or more of both, than in the other flowers of the same inflorescence."

Finally, he finds that in forms such as *Stellaria media*, and *Ranunculus ficaria*, which have a long flowering season, there is a noticeable decrease in the number of stamens and carpels during the flowering season, regardless of their location on the inflorescence, — a result which is closely paralleled by my work on *Aster prenanthoides* Muhl.

ausdehnt, und zur Bestimmung der constanten Mischcurve der Art ist eine sehr grosse Anzahl von Zählungen nöthig."

I agree with Ludwig that a large number of counts is necessary for the determination of the constants in material of this kind; but how great must it be? It is to be noted that, in his tables representing the variation in number of achenes in the heads of *Ranunculus acris* L., he gives the results of two sets of observations, each consisting of counts of 1000 heads. The maxima of the two multimodal curves formed, alternate with each other, and their summation gives but few maxima where they ought (?) to be, — the material is insufficient; yet he makes virtue of the fact that the summation of Lucas's data, only 831 counts, presents maxima upon the series of Fibonacci.

This series of Fibonacci, which is of recognized importance in the phyllotaxy of flowering plants, should be accepted with caution as the key to all variation among plants. The members of the series, along with Ludwig's "Unterzahlen," which are made up from the numbers of the Fibonacci series by multiplication or addition, — *e.g.*, $10 = (2 \times 5)$, $29 = (8 + 21)$, etc., — include so large a proportion of all the smaller numbers that many modes must fall on or near one of them, even if there be no fundamental relation existing between this complex series and the number of floral parts or other organs under consideration. To account for modes which do not fall on any of these, Ludwig creates the "Scheingipfel," which is formed by the overlapping of curves having their modes on adjacent numbers of the Fibonacci-Ludwig complex. Thus, if the maximum falls upon 9, it is a "Scheingipfel" formed by the union of curves having maxima upon 8 and 10; if it fall upon 11, it is made up of curves having maxima upon 10 and 13, etc. It is evident that such a scheme will furnish an explanation of almost any condition which might arise.

In conclusion, it needs to be said that there remains much to be done in determining the many causes of variation. The quantitative study of variation shows only the existing condition of the material studied. It deals only with results, and if there has been no intentional selection of material, it indicates nothing as to the causes which have brought about those results.

While deprecating the selection of material on false bases, I take it that intelligent selection of material existing under known conditions is more certain to give valuable results than at-random selection, which, while sure to select, ignores the conditions under which the selection is made.

Until we know the causes of variation and how great degree of variation may be produced by how slight causes, all generalizations based upon limited observations should be accepted with caution. Granting that observers have no preconceived notions as to what they ought to find, the conditions found by each investigator are true of the material upon which he worked, but how true his general conclusions are, further investigation alone can tell.

If every valley and hillside is to have its own place-mode and every day and every season is to bring forth a changed condition in the variable characters of its living forms, only a universal collection of material covering a long period of years can give us true constants which may be verified by a repetition of the process.

VI. Summary.

Quantitative studies were made upon the bracts, rays, and disk florets of four species of Aster growing at Yellow Springs, Ohio.

A close correlation was found between bracts and rays, and attributed to the fact that the rays are axillary to the bracts.

The degree of imbrication of the bracts was observed to bear a relation to the number of empty bracts.

Curves and "constants" were determined for the material of the four species studied. "Constants" determined for several individuals of *A. puniceus* L. growing in identical surroundings indicated how great variations may exist in the variability "constants" of individuals.

Studies upon successive collections from a single group of specimens of *A. prenanthoides* Muhl. showed that the number of bracts, rays, and disk florets all decrease continuously from the beginning to the end of the flowering season, and that the

character of the curves and the position of their means and modes likewise change continuously.

I wish to express my thanks to Prof. W. L. Tower for his kindly interest and helpful suggestion during the prosecution of these studies, and also for the revision of the manuscript.

YELLOW SPRINGS, OHIO.
June 25, 1901.

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EDITORIAL COMMENT.

In order that our summaries may correspond, so far as possible, to the calendar year, "The Quarterly Records of Gifts, Appointments, Retirements, and Deaths" will hereafter appear in the numbers for February, May, August, and November. Under the heading "Educational Gifts" we have included all donations from private individuals for distinctively educational purposes, so far as they have come to our notice. We have included, therefore, not only gifts to schools and colleges, but those to libraries and museums, since in many cases it is otherwise impossible to draw a sharp line. We have not included in our summaries appropriations by the national, state, or local governments for educational purposes, nor have we included the formal transfer by Mrs. Stanford to the Leland Stanford Junior University of securities and other property, with an estimated value of $30,000,000, the largest single gift for educational purposes in the history of the world. Yet, omitting these, the gifts for the year 1901, as catalogued in our pages, foot up the enormous sum of $43,233,635. These recent educational gifts, increasing in amount as the years go by, are of immense importance in any estimate of the future of education in America, and in the opinions of some are not an unmixed blessing. Certainly, so far as the financial basis is concerned, the United States will soon stand ahead of any country in the world, but the question cannot help suggesting itself, Will it advance as rapidly and to such prominence in intellectual matters as it does in the material side of education?

While speaking of our Record it may not be out of place to say that since the *American Naturalist* came into the hands of the present management its notices of appointments, resignations, and deaths has been the most complete published. In these years 1717 personal notes have appeared under these three headings.

NOTES AND LITERATURE.

GENERAL BIOLOGY.

Mechanism and Vitalism. — Under the title of *Mechanismus und Vitalismus*, Prof. O. Bütschli has published in brochure form his address before the International Zoölogical Congress which met in the summer of 1901 in Berlin. Bütschli points out that the modern thinkers and investigators who stand for the doctrine of vitalism, and who are often referred to as "Neovitalists," do not in reality uphold anything fundamentally new, since there is no important distinction between the old and the new vitalism. Both the old and the new doctrine rest on the assumption that life and life-processes cannot be understood, or at least not entirely understood, except as the outcome of a special principle, or force, or of a "peculiar something," which is not present in inorganic or rather dead substances. The new doctrine of vitalism goes further, perhaps, in maintaining that the purely causal mechanical point of view of living phenomena is also as correct as the teleological, but even this is not a real departure from the older view, since the latter also expressed itself causally in the sense that the postulated vital force, that was supposed to account for the phenomena of life, acted according to the causal formula.

Bütschli begins by defining as briefly as possible his own general standpoint in regard to the theory of knowledge. A few pages are given up to the discussion of the *Ego* and the *Object*. It is not clear why the author should introduce his subject by such a thread-worn metaphysical discussion, which is likely, in our opinion, to discourage and disappoint the reader at the start, but the mantle of metaphysics falls on the seventh page, and the author returns to his real theme.

Bütschli states that by "mechanism," as applied to the organism, he does not mean simply the kind of mechanics that deals with motion and with equilibrium, but rather the conception of the organism on the bases of regular sequence of cause and effect in the same way in which we account for inorganic changes. "A purely mechanical conception is impracticable even in inorganic phenomena."

There follows an explanation of that most evasive of German words, "Auslösung," and its relation to causal phenomena. Bütschli then

proceeds to give a neat and convincing account of what is meant by a "descriptive" science and points out how a number of modern critics have misinterpreted the term. In their desire to show that all science is only descriptive they have failed to discriminate between orderly sequences, such as night following day, and necessary sequences, such as the explanation of the alternation of night and day as the outcome of the revolution of the earth on its axis, etc.

After discussing whether the simplest organisms — bacteria for instance — might be accounted for as the outcome of a physico-chemical accident, Bütschli asks: If this is possible, can the same assumption account for the highly complicated organism? This leads to a discussion of what is meant by "chance" or "accident." Bütschli points out that one of the chief peculiarities of living things is their power of reproducing other living things like themselves, so that if a given form once arose by chance, its continuation does not any longer depend on chance, since by its own nature it reproduces that special group of "accidents" that brought it into existence. The argument leads naturally enough to Darwin's hypothesis of the origin and survival of chance variations. Bütschli affirms his belief that up to the present no better hypothesis has been advanced to explain the adaptation of organisms to their environment. There follows an admirably clear analysis of what we mean by adaptation. It would lead too far to enter into this discussion, but we cannot refrain from expressing great admiration for the clearness and ability with which the subject is handled.

Pflüger's "teleological causal law" is skillfully divested of its metaphysical covering. Bütschli points out that the same law is equally applicable to a steam engine with a regulator. Cossmann's recent argument, in which he attempts to demonstrate a special "biological" sequence of causes and effects in organisms as contrasted with the sequence in the inorganic world, is severely criticised and its fallacy exposed.

Bütschli points out that Driesch's demonstration of vitalism rests on a very doubtful assumption. If it could be shown, as Driesch claims, that the reorganization of a piece of an egg or of an adult into a new whole with proportionate parts is a phenomenon peculiar to living things, then Bütschli admits that Driesch might make good his position, but that this is true is by no means proven to be the case. As a parallel inorganic phenomenon it is pointed out that a drop divided in two forms two new drops. Again, if a drop of some

substances is drawn out into a cylindrical thread, the latter will, under certain conditions, break up into a series of drops of definite size and of definite distances from each other. If two such cylindrical threads of unequal size are treated in the same way, they will form drops proportionate to the original sizes of the threads, etc. Here Bütschli claims we find an analogy to the tripartite division of the archenteron of the gastrula of the sea urchin. I may add that a still more striking parallel is to be found in the behavior of the "fluid crystals" described by Lehmann. If a portion of one of these is pinched off, it shows from its optical behavior that it has assumed the crystal condition characteristic of the original whole.

Bütschli concludes: The old and the new vitalism alike emphasize the presence of the unsolved riddles of biology and express a doubt as to their solution on mechanical principles. They teach us nothing about the organism, since the very premises of the vitalistic argument rest on the assumption of an ultimate orderly action that is in itself beyond our comprehension. Therefore, we may well say that we can only grasp those parts of the phenomena of life that we can interpret by means of physico-chemical principles. T. H. M.

Biometrika, "a journal for the statistical study of biological problems," makes its first appearance with the number for October, 1901. Its aim is to serve "as a means of collecting under one title biological data of a kind not systematically collected or published in any other periodical," and of spreading such a knowledge of statistical theory as may be requisite for scientific treatment of the data collected. The editors are "in consultation with Francis Galton," Professors W. F. R. Weldon, Karl Pearson, and C. B. Davenport. *Biometrika* is published in Cambridge, England, at the University Press, a sufficient guarantee that the excellent form given to the initial number will be maintained. An excellent portrait of Darwin, from the Pinker statue at Oxford, forms the frontispiece. An editorial by Francis Galton is followed by papers by Professor F. Ludwig, Miss M. Beeton and Professors Karl Pearson, W. F. R. Weldon, and other well-known students of variation.

ZOÖLOGY.

Biogeographical Regions. — A valuable contribution to biogeography has recently been published by Jacobi.[1] The author has accepted the modern views on geographical distribution, and especially the fundamental idea that the present distribution does not correspond, in many cases, to the present conditions of life, but has often its origin in the past, and indicates conditions prevailing in former geological periods. He points out that the best zoögeographical divisions proposed by previous authors have not covered all cases, and cannot do so, because the past conditions were often directly the opposite to the present ones. Nevertheless, he tries to give a scheme that is intended to unite past and present conditions,[2] and selects Lydekker's division in three realms (Arktogæa, Neogæa, and Notogæa) as the most appropriate, since he believes that it *accounts best for the distribution of mammals and birds from the beginning of Tertiary times.*

Aside from the question whether it is necessary at all to have any biogeographical realms or regions, we cannot agree with this idea that biogeography ought to unite past and present conditions into *one* scheme; indeed, in many cases it is directly impossible to do so, since we do not see any way to reconcile connection and disconnection. And in most cases it would amount just to this, to bring under one head certain parts of the earth's surface which are now connected, while they were formerly disconnected, — or *vice versa.* Believing this to be an impossible task, we have always advocated another method of investigation, namely, the attempt to establish the present conditions of life (not the actual distribution of animals or plants) and to divide the earth into regions accordingly. These regions refer only to the *present* time, and by comparing this scheme with the actual distribution of animals, those cases which do not agree with it are at once revealed. This method calls our attention to those facts in distribution which need special investigation and explanation, and in most cases we shall be able to account for them

[1] Jacobi, A. Lage und Form biogeographischer Gebiete, *Zeitschrift der Gesellschaft für Erdkunde zu Berlin*, Bd. xxxv, Heft 3 (1900), pp. 147–238. 2 pls.

[2] The same idea has been advocated by Prof. H. F. Osborn (*Science*, April 13, 1900, p. 563), who says: "This, then, is our problem, to connect living distribution with distribution in past time and to propose a system which will be in harmony with both sets of facts."

by supposed changes in the conditions of life that have taken place during the earth's history.

The investigation of instances of the latter kind forms a large part in Jacobi's paper, and he has collected valuable material which tends to show that certain parts of the earth's surface, in their fauna and flora, possess a uniformity which is inexplicable by the present conditions. He calls those parts "areas of dispersal" (*Ausbreitungsgebiete*) and indicates them on his map (Pl. VII). There are fifteen of them:

1. Greenlandian.	6. Arabian.	11. Philippinian.
2. Lusitanian.	7. Indo-African.	12. Southern Japanese.
3. Mediterranean.	8. Antarctic.	13. Siberian.
4. Sarmatian.	9. Papuan.	14. Beringian.
5. Iranian.	10. Farther Indian.	15. Central-American.

Of these, the 4th (southern Russia and Turkestan), the 5th (Persia), the 10th (Farther India), and the 15th (Central America) are situated on continents and do not present any remarkable features, since they are not opposed to the present conditions.

The 2d, connecting England with western France and Spain, the 3d, connecting the Mediterranean countries, the 9th, connecting New Guinea with Australia, the 11th, connecting the Philippine Islands with each other and with Formosa, the 12th, connecting South Japan with Korea and China, the 13th, connecting North Japan with Siberia, and the 14th, connecting Siberia and Alaska, are well known and have been generally accepted as well established.

The chief interest centers in the remaining areas of dispersal, namely, the 1st (connection of East Greenland with Spitzbergen, Norway, and Scotland), the 6th and 7th (connection of East Africa and India, partly by way of Abyssinia and Arabia, partly by way of Madagascar and the islands of the Indian Ocean), and the 8th (connection of South Africa, Australia, New Zealand, and South America with Antarctica). Indeed, none of these connections is new to science, and some of them have been repeatedly discussed lately, but it is interesting that Jacobi's studies have led him also to the assumption of the former existence of these very important biogeographical relations, which can only be explained by the theory of a former connection of the respective parts by land. In the demonstration that such conditions must have existed in former times, and in the collection of known facts as well as introduction of new ones, which tend to support this assumption, lies the chief value of

this paper, and thus it will be of great use to any one who proposes to study these highly interesting zoögeographical questions.

A. E. O.

The Apogonoid Fishes of Japan. — Jordan and Snyder continue their monographic reviews of the various groups of Japanese fishes with an account of the cardinal fishes, or Apogonidæ. Seventeen species are described, most of them being figured. Six of these are new, one new genus, Telescopias, being recognized. The authors have overlooked the fact that Dr. Günther has substituted the generic name of Synagrops for Melanostoma, which is preoccupied. D. S. J.

Jenkins on Hawaiian Fishes. — In the *Bulletin of the United States Fish Commission*, Dr. O. P. Jenkins continues his studies of the very rich collection of Hawaiian fishes made by him in the summer of 1889. Fifteen species are described and figured as new: *Sphyræna helleri*, *Sphyræna snodgrassi*, *Anthias fuscipinnis*, *Aphareus flavivultus*, *Eupomacentrus marginatus*, *Chromis velox*, *Chætodon mantelliger*, *Chætodon sphenospilus*, *Ostracion camurum*, *Ovoides latifrons*, *Tropidichthys jactator*, *Eumycterias bitæniatus*, *Scorpænopsis cacopsis*, *Parapercis notostigma*, *Brotula marginalis*. Later investigations of the Hawaiian Commission, of which Dr. Jenkins is a member, show that *Chætodon mantelliger* is the original *Chætodon miliaris* of Quoy and Gaimard; *Parapercis notostigma* has been recently and earlier described as *Percis schauinslandi* by Steindachner.

D. S. J.

Seale on Hawaiian Fishes. — In an "Occasional Paper of the Bernice Pauahi Bishop Museum of Polynesian Ethnology and Natural History," Mr. Alvin Seale, curator of ichthyology, describes six new species of fishes from Honolulu, illustrating them with photographs of the type specimens.

These species are: *Epinephelus quernus*, *Novaculichthys tattoo*, *Serranus brighami*, *Balistes fuscolineatus*, *Monocanthus albopunctatus*, *Thalassoma berndti* (misprinted "berendto").

Of these the *Serranus brighami* seems to be related rather to Etelis than to Serranus.

D. S. J.

Starks on the Synonymy of the Fish Skeleton. — In the *Proceedings of the Washington Academy of Sciences*, Mr. Edwin Chapin Starks gives a comparative study of the names applied to the bones of fishes. This will prove a great convenience to students

of osteology, as giving a clue to the labyrinth of names due to the premature assumption of homologies between the fish skeleton and that of man.

There are now few fields in zoölogy so little worked and at the same time so repaying as that of the comparative osteology of the bony fishes. Most anatomists treat the group as though all bony fishes were alike in their osteology.

The paper is illustrated by plates of the skeleton of the "Striped Bass," the best drawing of the fish skeleton yet published. These are by Mrs. Chloe Lesley Starks.

D. S. J.

Eigenmann on a New Psenes from Newport, Rhode Island. — In the *Bulletin of the United States Fish Commission*, Dr. C. H. Eigenmann describes a new oceanic fish from the Gulf Stream off Newport, under the name of *Psenes edwardsi*. It was found, as is often the case with other nomeid fishes, under a Portuguese man of war. The diagnosis of the family Nomeidæ is amended by Dr. Eigenmann. The group possesses, like the Stromateidæ, denticles in the throat, and, according to Eigenmann, it differs only in the larger number of the vertebræ. But in Stromateidæ, as in Nomeidæ, the vertebræ are in increased numbers, 30 to 36. I know at present no real difference between the two families.

D. S. J.

Eigenmann on the History of the Young Squeteague. — In the *Bulletin of the United States Fish Commission*, Dr. Eigenmann gives a useful study of the development of the young weakfish, or squeteague, *Cynoscion regalis*.

D. S. J.

Nishikawa on the Development of the Japanese Anchovy. — In the *Journal of the Japanese Fisheries Bureau*, Mr. T. Nishikawa gives a similar study of the development stages of the common anchovy of Japan, *Engraulis japonicus* Schlegel. By some error, Mr. Nishikawa accredits the name *japonicus* to Houttuyn. Houttuyn's *Atherina japonica*, however, was not an anchovy but a sardine.

D. S. J.

Boulenger on the Classification of the Trachinoid Fishes. — In the *Annals and Magazine of Natural History*, Dr. G. A. Boulenger has a very valuable study of the osteology and relationships of the group of fishes called Trachinoidea.

The family of Trachinidæ was established by Dr. Günther in 1861, for spiny-rayed fishes, with perfect ventrals, short first dorsal, and lacking the special traits of other related groups.

The family was evidently a provisional one, and several writers, notably Dr. Gill and Dr. Bleeker, have noted the incongruity of its members and suggested the removal of certain of its subdivisions to other groups. Nevertheless, in default of any study of the skeletons, these families have been kept in some sort of association by subsequent writers. The study of the skeletons shows plainly the necessity of a complete revision of the assemblage. This has been done by Dr. Boulenger.

Dr. Boulenger shows first that in Trachinus the scapular fenestra, as in the codfishes, lies between the scapula (hypercoracoid) and the coracoid (hypocoracoid) instead of piercing the former, as in ordinary fishes. This character is shared by Notothenia, Chænichthys, Parapercis, Eleginops, Harpagifer, Trichonotus, Callionymus, and their relatives. All these lack the supraocular lamina, which is present in Trachinus. Trichonotus and Callionymus show other osteological characters, which separate them as families, although not invalidating their general trachinoid relationship. The genus Percophis agrees closely in osteology with Trachinus, but the scapular fenestra is entirely within the scapula as in the percoid fishes.

Bembrops, Chimarrhichthys, and Leptoscopus agree with Notothenia in the absence of a subocular lamina, but differ in having the fenestra within the scapula. These forms show affinities with the Batrachoididæ. Boulenger refers them to Leptoscopidæ.

Dactyloscopus, which has reduced ventrals and the pectoral arch of Clinus, is regarded as a true blenny, notwithstanding its apparent likeness to Uranoscopus. Gillellus, Dactylagnus, and Myxodagnus will doubtless go with it.

Uranoscopus and its allies (Anema, Ichthyscopus, Kathetostoma, Ariscopus) have also the scapular fenestra in the scapula, but show a number of other osteological peculiarities. They are, however, unquestionably trachinoid in general relationship.

The group Trachinoidea in Boulenger's view, therefore, includes the following families : Trachinidæ, Nototheniidæ, Percophidæ, Leptoscopidæ, Uranoscopidæ, Trichonotidæ, and Callionymidæ. All these agree with the Blenniidæ, Batrachoididæ, Ophidiidæ, and Gadidæ in having jugular ventrals, in which the fin rays are frequently not of the normal number which is I, 5. For the division or suborder of fishes thus characterized, containing these families and their allies, Dr. Boulenger proposes to revive the old name "Jugulares."

The remaining genera referred to Trachinidæ or to Trachinoidea show no real affinity with Trachinus, Callionymus, and Uranoscopus.

They have not jugular ventrals and should be removed to other parts of the system.

The Chiasmodontidæ (including Chiasmodon, Pseudoscopelus, and apparently Champsodon) have the ventrals rather abdominal than thoracic, not being connected with the pectoral arch, or in Champsodon joined by ligament only. These may be Percesoces, but that is very unlikely and their real affinities are doubtful.

The Trichodontidæ (Trichodon and Arctoscopus) are percoids, most nearly related to the Latrididæ.

The Sillaginidæ are, as supposed by Cavier, most nearly allied to the Sciænidæ.

Most of the remaining genera agree closely in skeletal characters, notwithstanding their variations in external appearance, and their actual relationships are altogether percoid, approaching closely to the genus Plesiops, which Boulenger ranges among the Serranidæ of the Anthias group. These constitute the family Pseudochromididæ, composed of Pseudochromis, Cichlops, Opistognathus, Latilus, Caulolatilus, Malacanthus, Bathymaster, and their allies. This family seems to the writer still very heterogeneous. Bathymaster has a greatly increased number of vertebræ, Pseudochromis has two lateral lines, and Opisthognathus differs superficially in many ways from Latilus. Cepola, not mentioned by Boulenger, must lie near this group as a distinct family, Cepolidæ. Pinguipes differs from all this in lacking the supraocular lamina. It forms a distinct family, Pinguipedidæ.

D. S. J.

Jordan on Distribution of Fishes. — In *Science*, Dr. Jordan has an extended account of the origin of the fish fauna of Japan, with deductions of general application from the relation of the Japanese fauna to those of other regions.

He finds no evidence from the fishes of a direct connection between Japan and the Mediterranean, and no evidence of the submergence of the Isthmus of Suez. In the large identity of genera, and the divergence of species on the two sides of the Isthmus of Panama, he finds evidence of former submergence (perhaps Miocene) but none during the lifetime of the present species. He does not find in the wide distribution of the Antarctic fresh-water troutlike genus, Galaxias, certain evidence of the former union of South America and Australia in Antarctic Continent, but would accept the theory on geological evidence.

In a note in a subsequent number of *Science*, Dr. A. E. Ortmann claims the existence of adequate geological evidence of the former extension of the continent "Antarctica." In this case the distribution of Galaxias would be easily explained, but it could be conceivably explained without it. Dr. Ortmann notes also evidence of the faunal union of Japan with Europe when the climate of Siberia was much warmer than now. This evidence is drawn from the distribution of Crustacea. The distribution of the fishes does not, however, yield evidence of this kind.

D. S. J.

Jordan and Snyder on the Puffing Fishes of Japan. — In the *Proceedings of the United States National Museum*, Jordan and Snyder continue their monographic reviews of the fishes of Japan, treating of the gymnodont fishes, or puffers. Twenty-seven species are described, belonging to eight genera. Four new species are figured, besides several previously known. The authors unite the genus Lagocephalus with Spheroides, finding a continuous series from one extreme to the other. In like manner, Ovoides is merged into Tetraodon.

D. S. J.

Kerr on the Paired Limbs of Vertebrates. — In the *Proceedings of the Cambridge Philosophical Society*, Mr. Kerr discusses the question of the origin of the paired limbs in vertebrates. He finds the view of Balfour and others, that these limbs had their origin in a lateral fold, without adequate support in fact or in theoretical considerations.

The view of Gegenbaur, that they arose from modification of the gill septa separating gill slits, he also criticises unfavorably.

As a provisional hypothesis he brings forward the theory, already foreshadowed by others, that the vertebrate limbs are modified external gills. The close association of the fore limbs and gills shown in Mr. Kerr's plates of the young Lepidosiren, in another paper, seems to lend color to this theory.

D. S. J.

Notes on Fishes. — Professor Alfredo Dugès of Guanajuato has recently sent a bottle of little fishes taken in the very hot spring at Ixtlan, in the northwestern part of the Mexican state of Michoacan. These belong to the species described by Woolman as *Gambusia infans*. It is a valid species, distinguished by its small size and plain color among other things, but the original description is at fault in

placing the beginning of the dorsal opposite that of the anal. As usual in this group, the dorsal is considerably beyond the front of the anal fin.

D. S. J.

In the *American Naturalist* for March, 1901, I published a note in regard to the planting of fish in Crater Lake, Oregon, in the summer of 1900, by the Rev. Edwin Sidney Williams of Saratoga, Cal., who was of the opinion that fish had not previously existed in the lake.

Mr. J. S. Diller of the United States Geological Survey has recently informed me that he visited the lake in July last and saw in it a number of fish, ranging in size from six to thirty inches, the largest ones in many cases being white upon the back or other parts of the body as if diseased, and on this account being readily seen. The smaller ones were in good condition. The fish were spotted like the large trout of the Klamath Lake region. None of them were captured. Mr. Diller had no difficulty in getting them to take grasshoppers or white pumice when thrown into the water.

From the large size of some of these fishes it would appear that they existed in the lake prior to Mr. Williams's visit. They were doubtless results of some earlier plant from the Klamath.

D. S. J.

About March 10, 1897, the State Fish Commission of California, through Mr. Norman B. Schofield, assistant, planted 855,000 young fry of the quinnat salmon in Paper Mill Creek, the chief tributary of Tomales Bay.

As this stream has never contained any salmon, and is open to observation for its length of twenty-five miles, this operation gave especially good opportunities for the observation of the young fish.

They soon dropped down from the stream in which they were planted, tail first, salmon fashion, and in forty-five days were found in considerable numbers in brackish water. Some of the young salmon were taken in April at Marshall, fifteen miles down the bay. In June they disappeared entirely.

The next year, 1898, two million additional salmon fry were placed in Paper Mill Creek.

Recently, about Nov. 1, 1901, four and a half years after the first planting, an adult male quinnat salmon weighing about seventeen pounds was sent to me from Mr. A. D. Hochfort of Point Reyes, as one of a large run of strange fish seen for the first time in Paper Mill Creek.

D. S. J.

BOTANY.

Chamberlain's "Methods in Plant Histology." [1] — The thin volume at hand is based on a series of elementary articles in the *Journal of Applied Microscopy* dealing with methods of studying the finer structure of plants. It is, therefore, a discussion of methods rather than a treatise on plant histology. Chapters dealing with reagents, methods of killing and fixing, staining, sectioning, and mounting deal with the processes named. The directions are given in a clear, straightforward style, and numerical data appear where most desirable. The preparation of reagents is described fully enough, and the absence of citations of indefinite quantities and time limits, which often renders useful books less useful than they might be, is commendable.

The second part deals with the most useful methods of preparing material, from the lowest to the highest groups of plants, and special methods and devices for difficult types of plant life are described. Some of the main features to be looked for are indicated, mainly as a means of judging of the success of the preparation.

Although in no sense a complete work, one rendering Lee's *Vade Mecum* or Zimmermann's *Microtechnique* less necessary, most teachers of botany not themselves primarily histologists will find this volume a very useful addition to their shelf of ready reference books.

R. H. T.

Notes. — Very substantial evidence of activity in the botanical laboratory of the Imperial University of Tokyo, Japan, under the direction of Dr. M. Miyoshi, professor of botany, is at hand in the shape of several papers published in the *Journal of the College of Science* during the current year.

K. Saito [2] presents an anatomical study of the most important plant fibers of Japan, giving attention especially to those derived from bast cells. The shape, dimensions, markings, contents, and wall structure are indicated, and the reactions of the walls to the most important reagents stated. Several points of interest bearing on the developmental history of certain of these fibers have been

[1] Chamberlain, Charles J. *Methods in Plant Histology.* Chicago, University of Chicago Press, 1901. 159 pp.

[2] Saito, K. Anatomische Studien über wichtige Faserpflanzen Japans mit besonderer Berücksichtigung der Bastzellen. *Journ. Coll. of Sci., Imp. Univ. Tokyo*, vol. xv, pt. iii (1901), pp. 395–462. 2 pls.

worked out. The work closes with a key for the microscopical identification of the fibers of Japan.

S. Kusano[1] reports investigations made to determine the amount of transpiration taking place in evergreen trees of Japan in winter. He finds that the giving off of water from the foliage at no time actually ceases, even though the minimum temperature (in Hondo) falls to a point several degrees below zero. The time of least transpiration is, however, found to coincide with this minimum, falling in the month of January. Since photosynthetic activity has been shown by Miyake not to come to a complete standstill in winter in the latitude concerned, Kusano concludes that the abundance of evergreen trees in Japan is chiefly due to its favorable climate.

H. Hattori[2] has studied the action of copper sulphate on certain plants during considerable periods and agrees with those who have previously investigated the effects produced by copper salts in finding that it is extremely toxic in its action. Amputated conifer twigs, seedlings, pot plants, and molds were used in his experiments. Little that is entirely new has been developed, but a number of interesting things are reported. Among others is the fact that copper sulphate in a solution containing 0,000.001 per cent of the salt is not harmful to corn seedlings cultivated in it for considerable periods. The capacity of the soil for fixing considerable quantities of salt supplied to it in solution accounts for the greater amount of copper endured by plants grown in pots of earth. Molds grown in copper containing culture media were found to be stimulated by minimal amounts of the metal, 0,004 per cent to 0,008 per cent being indicated for Aspergillus and Penicillium, respectively.

T. Inui[3] has studied the lower plant organisms connected with the preparation of awamori, an alcoholic, whisky-like beverage brewed in the Luchu Islands (situated between Formosa and the Kiushu Islands).

Boiled rice or millet is inoculated from material of former cultures and, after sufficient growth has been made first on the grain in a

[1] Kusano, S. Transpiration of Evergreen Trees in Winter. *Journ. Coll. of Sci., Imp. Univ. Tokyo*, vol. xv, pt. iii (1901), pp. 313–366. 1 pl.

[2] Hattori, H. Studien über die Einwirkung des Kupfersulfats auf einige Pflanzen, *Journ. Coll. of Sci., Imp. Univ. Tokyo*, vol. xv, pt. iii (1901), pp. 371–394. 1 pl.

[3] Inui, T. Untersuchungen über die niederen Organismen welche sich bei der Zubereitung des alkoholischen Getrankes "Awamori" betheiligen, *Journ. Coll. of Sci., Imp. Univ. Tokyo*, vol. xv, pt. iii (1891), pp. 465–478. 1 pl.

moist atmosphere and afterwards in a more watery preparation, the alcoholic product is obtained by distillation. The author has isolated several new forms from the material used, — *Aspergillus luchuensis*, related to *Aspergillus wentii* Wehmer; *Aspergillus perniciosus*, near the latter; and *Saccharomyces awamori*. He reports the presence of a species of Monilia and of *Saccharomyces anomalus*, which latter form produces the characteristic aroma.

Professor Miyoshi[1] makes a second contribution to his study of a mulberry disease called "Ishikubyo," and comes to most interesting conclusions. The injury is due to a lack of proper balance in the tissue development of the plant. The leaves manufacture more carbohydrates than the conducting system is able to withdraw during the usual time. The woody tissue of affected plants in all parts is also underdeveloped, and a diminished water transpiration results. This account is the more interesting since physiological derangements are not often traced back to ill-balanced tissue formations.

In this connection it may be noted that Suzuki, investigating this disease in the light of Woods's work on the "mosaic disease" of the tobacco plant, has come to the conclusion that in the mulberry, as in the tobacco, the trouble is due to an overproduction of oxydizing enzymes accompanied by a more or less advanced state of starvation.

Another article by Professor Miyoshi[2] reveals an extremely perfect means for securing spore dissemination in a new tree-inhabiting Japanese lichen named by the author *Sagedia macrospora*. The rounded sporocarps lie imbedded in the thallus until ripe, when, through the weakening of the tissues surrounding them, they separate from the thallus as free rounded masses. On absorbing water, the sporocarp expands and opens out by means of the hygroscopic properties of the walls, exposing the hymenium. The spore-containing sacs rupture, thus freeing the spores. The fixation of the free sporocarp to the bark of the tree is secured by the sticky outer surface. The sporocarps by repeated moistening and drying can be made to open and close many times, even after killing the living parts by heat or other means.

[1] Miyoshi, M. Untersuchungen über die Schrumpfkrankheit ("Ishikubyo") des Maulbeerbaumes. II. Bericht. *Journ. Coll. of Sci., Imp. Univ. Tokyo*, vol. xv, pt. iii (1901), pp. 459–464.

[2] Miyoshi, M. Ueber die Sporocarpenevacuation und darauf erfolgendes Sporenausstreuen bei einer Flechte. *Journ. Coll. of Sci., Imp. Univ. Tokyo*, vol. xv, pt. iii (1901), pp. 367–370. 1 pl.

Dr. Robinson's admirable presidential address before the Botanical Society of America, on "Problems and Possibilities of Systematic Botany," is printed in *Science* of September 27.

In the *Annals of Botany* for September, A. H. Church suggests that the substitution of a logarithmic spiral in place of the Archimedian spiral for the genetic and secondary spirals in phyllotactic studies refers this complex subject to a simple relation to the distribution of energy in the growing points.

Two additional works by Rafinesque — a *Florula Lexingtoniensis* and *The American Florist* — have been unearthed by W. J. Fox in the library of the Academy of Natural Sciences of Philadelphia, as appears from a note by him in *Science* of September 27.

An interesting addition to the literature of myrmecophilous plants is a paper presented at the meeting of the British Association last summer by Yapp. The ant galleries of two Malayan species of Polypodium are described. An abstract of the paper appears in *Nature* for October 17.

Papers on the fruit and seed structure (by Lonay) and leaf anatomy (by Goffart) of Ranunculaceæ are contained in the *Mémoires de la Société Royale des Sciences de Liége*, Vol. III, issued in July.

From a study of the anatomy and embryogeny of Nelumbo, H. L. Lyon concludes, in the current volume of *Minnesota Botanical Studies*, that the Nymphæaceæ should be transferred to the monocotyledonous group Helobiæ.

Robinia neomexicana is figured in the *Tidskrift* of the Svenska Trädgaardsföreningen for July–August.

Numerous popular varieties of *Begonia semperflorens* are figured from photographs in *Die Gartenwelt* of September 28.

Several Canadian gentians of the section Crossopetalæ are reviewed by Holm in the *Ottawa Naturalist* for November.

In Part II of Vol. VII of the *Contributions from the United States National Herbarium*, Mr. O. F. Cook adduces reasons for believing in the American origin of *Cocos nucifera*.

Scirpus supinus and its North American allies are reviewed by Fernald in *Rhodora* for October.

Mr. Eaton's ninth paper on Equisetum, in the *Fern Bulletin* for October, deals with *E. litorale*.

George H. Curtis has several lists of Kansas diatoms in the *Transactions of the Kansas Academy of Science* for 1899–1900.

The flora of the Azores receives an important addition through the publication in *Nyt Magazin for Naturvidenskaberne* of a paper on the fresh-water diatoms of the archipelago, by Holmboe. The species are European rather than American, and are believed to have been introduced by adhering to migratory birds.

Professor Hitchcock publishes a list of additions to his "List of Plants in my Florida Herbarium" in Vol. XVII of the *Transactions of the Kansas Academy of Science.*

Native Kansas plants adapted to cultivation are discussed by Grace R. Meeker in Vol. XVII of the *Transactions of the Kansas Academy of Science.*

The *Journal of Applied Microscopy* for October contains an illustrated article on the botanical laboratory and garden of the Imperial University at Tokyo, by Miyake.

An excellent portrait of the late Professor Cornu accompanies the September number of the *Bulletin de la Société Botanique de France.*

The *Fern Bulletin* for October contains a portrait of Thomas Meehan.

Trabut begins an illustrated article on caprification as practiced in Algeria, in the *Revue Horticole* of November 9.

A *Flora of the Presidency of Bombay*, by Theodore Cooke, is in course of publication by Taylor & Francis of London. The familiar sequence of orders of Bentham and Hooker is followed, and the single part thus far issued reaches into Rutaceæ.

An extensive report on a botanical survey of the Dismal Swamp region, by Thomas H. Kearney, forms the concluding number of Vol. V of the *Contributions from the United States National Herbarium*, issued under date of November 6.

The plants of western Lake Erie are considered as to their ecological anatomy and distribution by A. J. Pieters in a paper separately printed from the *Bulletin of the United States Fish Commission* for 1901.

Vol. III of Professor Greene's *Plantæ Bakerianæ* begins with a fascicle of thirty-six pages devoted almost exclusively to the description of new species from Mr. Baker's collections of 1901, on the Gunnison watershed of Colorado.

Four miscellaneous phanerogamous species from Colorado are described by Osterhout in the *Bulletin of the Torrey Botanical Club* for November.

Notes on the vegetation of the Cape Nome region, Alaska, by Collier, are included in the account of the Brooks reconnaissance of Seward Peninsula, recently published by the United States Geological Survey.

A monograph of the genus Sorbus, by Hedlund, constitutes No. 1 of Vol. XXXV of the *Kongliga Svenska Vetenskaps-Akademiens Handlingar.*

The volume of *Botaniska Notiser* for 1901 contains (pp. 33–72, 83–106, 155–158) a discussion by Hedlund of the forms of *Ribes rubrum* in the broad sense.

Under the name of *Pilea heptaphyllus*, Dr. Rarmíez describes and figures a representative of the Papayaceæ, in No. 1 of the current volume of *Anales del Instituto Médico Nacional*, of the city of Mexico.

An article on the preparatory fermentation of cacao, by Preyer, published in the *Tropenpflanzer* for April, is reprinted in translation in No. 10 of the *Boletin del Instituto Fisico-Geografico de Costa Rica.*

Various diseases of cacao and sugar cane and bud variation of the latter are discussed in No. 3 of the current volume of the *West Indian Bulletin*, of Barbados.

The chayote, *Sechium edule*, and its varieties are the subject of *Bulletin No. 28* of the Division of Botany of the United States Department of Agriculture, by Mr. Cook, special agent for tropical agriculture.

"Plant Breeding," an illustrated essay by Professor Hays of Minnesota, is published as *Bulletin No. 29* of the Division of Vegetable Physiology and Pathology of the United States Department of Agriculture.

Economic studies of *Rhizophora mangle*, *Avicennia nitida*, and *Eriodendron occidentalis* are published in No. 2 of the current volume of *Anales del Instituto Médico Nacional*, of Mexico, which also contains an article, by Martínez del Campo, on plants used in that country as diuretics.

A botanico-economic pamphlet on the Heveas, and the manufacture of rubber from them in Brazil, is issued as a public document by

Sr. J. Barbosa Rodrigues, director of the botanic garden of Rio de Janeiro, under the title *As Heveas ou Seringueiras*.

In No. 1197, "Advance Sheets," of *Consular Reports* is reprinted from the *Venezuelan Herald* an article by Dr. L. Morisse on rubber culture and manufacture in Venezuela from species of Hevea.

Dr. Peckolt is publishing a series of articles on the medicinal plants of Brazil in the *Berichte* of the German Pharmaceutical Society, and an alphabetic list of Portuguese and Tupi names for the economic plants of the same country in the *Pharmaceutical Archives*.

Stem and bark anatomical studies of Hamamelis (by Jensen) and Myrica (by Krembs) are published in the *Pharmaceutical Archives* for July.

From No. 3 of the *Bulletin du Jardin Impérial Botanique de St.-Pétersbourg* it appears that 33,697 species and varieties of plants were cultivated in that establishment last year. Some of the principal groups grown under glass are represented as follows: ferns, 798; orchids, 1433; cacti, 748; palms, 402; cycads, 60; conifers, 567; heaths, 186; aroids, 585; bromeliads, 420; succulents, chiefly agaves and aloes, 991. The plants grown in the open air comprise: trees and shrubs, 1240 species and varieties; perennials, 4385; and annuals, 1410. Over 37,000 persons visited the plant houses during the year.

It may not be generally known that an account of the government gardening in the District of Columbia is each year included in the *Report of the Chief of Engineers*. The volume for 1900 contains a list of the woody plants cultivated about the White House.

Sr. Rodrigues, director of the botanic garden of Rio de Janeiro, has begun the publication of a series of French *Contributions du Jardin Botanique de Rio de Janeiro* in quarto pamphlet form.

The tendency of some German investigators to confine their examination of the literature of subjects they investigate to publications by their fellow-countrymen is not inopportunely, if somewhat caustically, commented upon by Dr. MacDougal in *Torreya* for November.

An excellent portrait of the late Thomas Meehan is published in *Meehans' Monthly* for December, and a biographic sketch in the January number.

Vol. XXVI of the botanical *Bihang till Kongliga Svenska Vetenskaps-Akademiens Handlingar*, forming a thick volume, contains a wide

range of subjects, handled in the characteristically excellent Scandinavian fashion.

The *Ohio Naturalist* for November contains the following botanical articles: Tyler, "Geophilous Plants of Ohio," II; Kellerman, "Ohio Fungi Exsiccatæ," with reprint of original descriptions; Schaffner, "The Maximum Height of Plants," III.

Notes on the geotropism of fungus stipes, extrusion of the gametes of Fucus, and adaptation of *Spartina polystachya* to environment are published by E. B. Copeland in *Torreya* for November, in an account of the last season's work at the Cold Spring Harbor laboratory.

In Part II of the current volume of *Proceedings of the Academy of Natural Sciences of Philadelphia*, Dr. Harshberger discusses the limits of variation in plants, and Mr. Meehan contributes some observations on the upbending of mature wood in trees.

The anatomy of the conducting tissue of style and stigma is being considered by Guéguen in current numbers of the *Journal de Botanique*.

Eleanor E. Davie has compiled from the writings of the late W. H. Gibson an attractive little book on *Blossom Hosts and Insect Guests*, which, fully illustrated by the author's admirable drawings, is published by Newson & Co. of New York.

QUARTERLY RECORD OF GIFTS, APPOINTMENTS, RETIREMENTS, AND DEATHS.

EDUCATIONAL GIFTS.

Akron (Ohio) Public Library, $70,000, conditional from Andrew Carnegie.

Alfred University, $1000, by the will of E. P. Barker.

Amherst College, $1000, by the will of E. P. Barker.

Barnard College, Columbia University, a conditional gift of $200,000, from John D. Rockefeller.

Berea (Kentucky) College, $25,000, by the will of Mrs. George L. Stearns.

Butler (Indiana) College, $20,000 from Mr. and Mrs. E. C. Thompson of Indianapolis.

Bryn Mawr College, a conditional gift of $230,000, from J. D. Rockefeller.

Carnegie Institution, of Washington, D.C., $10,000,000 from Andrew Carnegie.

Carnegie Polytechnic Institute, of Pittsburg, $1,000,000, from Andrew Carnegie.

Chicago University, $1,250,000, from John D. Rockefeller.

Columbia University, $12,000, from Dean Lung, for the Chinese department.

Drury (Missouri) College, $8000, from E. A. Goodnow of Worcester, Mass.

Harvard University, nearly $100,000, from an anonymous donor, for a new building; $5000 for the Peabody Museum of Archæology, by the will of Mrs. S. D. Warren; $50,000, from Mr. T. Jefferson Coolidge, for physical research.

Kenyon College, $150,000, from various donors.

Manchester (New Hampshire) Institute of Arts and Sciences, $80,000, by the will of Mrs. Charles E. Balch of that city.

Metropolitan Museum of Art in New York, over $5,000,000, by the will of Jacob S. Rogers.

Montana Biological Station, $250, from Senator W. A. Clark.

Nashville, Tennessee, $100,000, from Andrew Carnegie, for a public library.

New York Botanical Garden, $3000, from Misses Oliva and Caroline Phelps Stokes.

New York Historical Society, $130,000, by the will of Miss C. B. De Peyster.

New York University, $20,200, from various persons, for a fellowship; $5000, from Miss Helen M. Gould, for a museum of pedagogy.

Northwestern University, $15,000, from an anonymous donor.

Oberlin College, $300,000, from various sources, thus securing the conditional gift of $200,000 from J. D. Rockefeller.

Palmer (Iowa) College, $30,000, from Mr. F. A. Palmer; $20,000, from other sources.

Princeton University, $2500 a year, for five years, from George A. Armour, for the classical seminary; $15,000, from the estate of John Sayre.

San Juan, Puerto Rico, $100,000, from Andrew Carnegie, for a public library.

Sheffield Scientific School of Yale University, $6000, from Edward B. Page, to found scholarships.

Springfield (Missouri) Public Library, $50,000, from Andrew Carnegie.

Syracuse University, $4000, from Mr. George C. French.

Tufts College, $50,000, and land valued at $40,000, by the will of Mrs. George L. Stearns.

Tuskegee Institute, $25,000, by the will of Mrs. George L. Stearns.

Union Christian (Indiana) College, $30,000, from Mr. A. B. Palmer of New York.

University of Pennsylvania, $25,000, from Messrs. Keasbey and Matteson; $5000, from John F. Wentz; $10,000, from the Frazer family; $20,000, from Dr. George Woodward, for a fellowship in physiological chemistry.

Vassar College, $30,000, from Miss Helen M. Gould, for scholarships; $110,000, from J. D. Rockefeller, for a new dormitory; $2000, from other sources.

Washington University, $100,000, from Mrs. James Finney How.

Wesleyan University, $125,000, from various donors for buildings.

Williams College, $5000, by the will of Mrs. S. D. Warren.

Worcester Polytechnic Institute, $30,000, from four trustees: S. Salisbury, C. H. Whitcomb, C. H. Morgan, and C. G. Washburn.

Yale University, $2500, from Mr. B. F. Barge.

APPOINTMENTS.

Wilhelm Arnell, lector in natural history in the University at Upsala. — Archibald A. Atkinson, assistant instructor in biology in the University of Oregon. — Dr. Georg Bitter, docent for botany in the Academy at Münster. — Prof. M. Büsgen, professor of botany in the school of forestry at Hannover-Münden. — Dr. Carl Busz, professor of mineralogy in the Academy at Münster. — Dr. M. Caullery, professor of zoölogy at Aix-Marseilles. — H. S. Davis, instructor in vertebrate zoölogy in the Washington Agricultural Experiment Station. — Frank S. Earle, assistant curator of the collection of fungi of the New York Botanical Garden. — Dr. Géza Entz, professor of zoölogy in the University at Budapest. — Dr. J. M. Flint, professor of anatomy in the University of California. — Willy Foy, director of the new ethnographical museum in Cologne. — Dr. Elisha H. Gregory, Jr.,

demonstrator of anatomy in the University of Pennsylvania. — W. Hammer, assistant in the Austrian Geological Survey. — Dr. Charles M. Hazen, professor of biology in Richmond (Virginia) College. — Mr. J. M. Hillier, keeper of the Museum of Economic Botany at Kew. — Mr. H. T. A. Hus, assistant in botany in the University of Amsterdam. — Henry M. Huxley, Hemenway fellow and assistant in anthropology in Harvard University. — J. T. Jenkins, lecturer on biology and geology in Hartley College, Southampton, England. — Dr. H. Joseph, docent for zoölogy and comparative anatomy in the University at Vienna. — S. Killermann, professor extraordinary of anthropology, zoölogy, and botany in the episcopal school at Ratisbon. — Dr. E. H. Kraus, instructor in mineralogy in Syracuse University. — Gustav Krause, district geologist of the Prussian Geological Survey. — Dr. A. A. Lawson, assistant in botany in Leland Stanford Junior University. — Dr. A. B. Macallum, professor of physiology in the University of Toronto. — Dr. A. Pelikan, professor of mineralogy and petrography in the German University at Prag. — Dr. R. G. Perkins, lecturer on bacteriology in the medical school of Western Reserve University. — J. M. Prather, instructor in biology in the University of Cincinnati. — Dr. K. Theodor Preuss, director's assistant in the royal museum at Berlin. — William Riley, instructor in entomology in Cornell University. — Dr. V. Schiffner, professor extraordinary of botany in the University at Munich. — Dr. Conrad von Seelhorst, professor of botany in the University at Göttingen. — Dr. Hans Solederer, professor of botany in the University at Erlangen. — Dr. Julius Stoklasa, professor of plant production in the Bohemian technical school at Prag. — Dr. E. Stolley, professor of geology in the Braunschweig Technical School. — Dr. Richard P. Strong, director of the government biological laboratory in Manila. — Dr. Roland Thaxter, professor of cryptogamic botany in Harvard University. — Dr. Victor Uhlig, professor of geology in the University at Vienna. — Dr. F. C. Waite, assistant professor of histology and embryology in the medical school of Western Reserve University. — Dr. Thomas L. Walker, professor of mineralogy and petrography in the University of Toronto. — William Watson, curator of the Kew Gardens. — H. N. Whitford, assistant in botany in the University of Chicago. — H. Winckler, first assistant in the Botanical Garden at Breslau. — Dr. Hans Winkler, docent for botany in the University at Tübingen. — Dr. A. Smith Woodward, keeper of geology in the British Museum. — Oscar Zeise, land geologist of the Prussian Geological Survey.

RETIREMENTS.

J. R. Jackson, from the keepership of the Museum of Economic Botany at Kew, after forty-three years of service. — George Nicholson, from the curatorship of the Kew Gardens, after twenty-eight years of service. — Dr. M. Ussow, from the directorship of the Zoötomical Institute of the University at Kasan. — Dr. Arthur Willey, from his position as director of

the Museum at Demerara, British Guiana. — Dr. Henry Woodward, from his position as keeper of geology in the British Museum. — Dr. John Young, from the chair of natural history in Glasgow, after thirty-five years of service.

DEATHS.

Lugui Maria D'Albertis, the ornithologist and explorer, in Sassari, early in September. — Dr. F. Arnold, lichenologist, in Munich, August 8, aged 73. — F. J. Birtwell, ornithologist, by an accident, in New Mexico, June 28. — David Carnegie, botanist and explorer, on the Middle Niger, Nov. 27, 1900, aged 30. — Albert Nelson Cheney, ichthyologist, at Glens Falls, N.Y., August 18. — Dr. J. H. Chievetz, director of the Anatomical Museum at Copenhagen. — Professor Miguel Colmeiro, director of the botanical gardens at Madrid, aged 86. — Dr. Carl Cramer, professor of botany in the Polytechnicum at Zürich. — William Doherty, entomological and ornithological collector in Nairoba, East Africa, May 25. — Dr. James Foulis, anatomist, in Edinburgh, October 17. — Prof. Dr. Robert Hartig of Munich forestry station, October 10, aged 62. — Prof. Alfonso Herrera, in Mexico, Jan. 27, 1901, aged 67. — Dr. Federico Horstman y Cantos, professor of anatomy in the University of Havana. — Dr. Georg Jablonowski, assistant in the Anatomical Institute in Berlin, September 28. — Josef Bernhard Juch, cryptogamic botanist, in Constance, August 14, aged 83. — Clarence King, director of the United States Geological Survey, 1878–1881, December 24, at Phœnix, Arizona. — James Walker Kirkby, geologist and student of fossil ostracodes, in Levin, Scotland, July 30, aged 66. — Dr. Arthur König, professor extraordinary of physiology in the University at Berlin, October 26, aged 45. — Prof. A. A. Kowalevski, formerly professor of zoölogy in the University at St. Petersburg, November 22. — Dr. Albrecht von Krafft of the Indian Geological Survey in Allahabad, in September. — Jacob Heinrich Krelage, a Dutch botanist, December 1, aged 76. — Henri Lacaze-Duthiers, the eminent French zoölogist, July 21. — L. Liener, botanist in Constance, in May. — Rev. Hugh Alexander Macpherson, a Scotch zoölogist, aged 43. — Prof. M. Märcher, director of the Agricultural Experiment Station at Halle, Oct. 19, 1901. — Mr. Thomas Meehan, the well-known botanist, at Germantown, Pa., November 29, aged 75. — Charles F. Mohr, botanist in Asheville, N.C., July 17. — Dr. H. Müggenburg, dipterologist in the Zoölogical Museum in Berlin, July 3. — Count Emil Neuhauss, student of Lepidoptera, April 21, aged 57. — Henri Philibert, professor of botany in Aix, May 14, aged 79. — Dr. Max Reess, formerly professor of botany in the University at Erlangen, in Klingenmünster, September 14, aged 56. — Louis Schneider, botanist and entomologist, in Philadelphia, aged 65. — Dr. L. Serrurier, formerly director of the ethnological museum in Leiden, in Batavia, July 7. — George B. Simpson, student of fossil Polyzoa and a well-known paleontological artist, at Albany, N.Y., October 15. — Dr. Henry Spencer

Smith, of London, October 29, aged 88. — Hermann Strecker, entomologist, at Reading, Pa., November 30, aged 65. — Dr. Peter Cormack Sutherland, formerly government geologist of Natal, in Durban, Nov. 30, 1900, aged 79. — Ralph Tate, professor of natural history in the University at Adelaide, Australia. — Dr. Wilhelm Tomaschek, professor of geography in the University at Vienna, September 9, aged 60. — Dr. A. A. Tokasy, head of the physiological laboratory at Moscow. — William West, student of fresh-water algæ, in India, of cholera, aged 26. — Lionel L. Wigglesworth, ornithologist, in Viti Levu, June 7, aged 37.

PUBLICATIONS RECEIVED.

(Regular exchanges are not included.)

BARTHOLOMEW, E. Ellis and Everhart's "Fungi Columbiani": Alphabetical Index. Centuries I–XV. — BEECHER, C. E. Studies in Evolution. New York, Charles Scribner's Sons, 1901. xxiii+638 pp., 34 pls. — CHURCH, A. H. On the Relation of Phyllotaxis to Mechanical Laws. Pt. i, Construction by Orthogonal Trajectories. Oxford, Williams & Norgate. 8vo, 78 pp., 10 pls., 34 text-figs. — COLE, G. W. Bermuda and the Challenger Expedition. Printed for private distribution. Boston, 1901. 16 pp. — COMSTOCK, J. H., and KELLOGG, V. L. The Elements of Insect Anatomy: an Outline for the Use of Students in Entomological Laboratories. Third edition, revised. Comstock Publishing Co., Ithaca, N.Y., 1901. 145 pp., 11 figs. — GETSINGER, E. C. A New Theory of Biology. Reprinted from the *Medical Times*, November, 1901. 17 pp. — Government Museum and Connemara Public Library: *Report on the Administration for the Year 1900–1901.* — MORGAN, T. H. Regeneration. Columbia University Biological Series, No. 7. New York, The Macmillan Company, 1901. xii+316 pp., 66 figs. $3.00. — United States Geological Survey. *Twenty-first Annual Report*, 1899–1900. Pt. i, xi+608 pp.; pt. vi, 656 pp.; pt. vi (*continued*), xi+634 pp.

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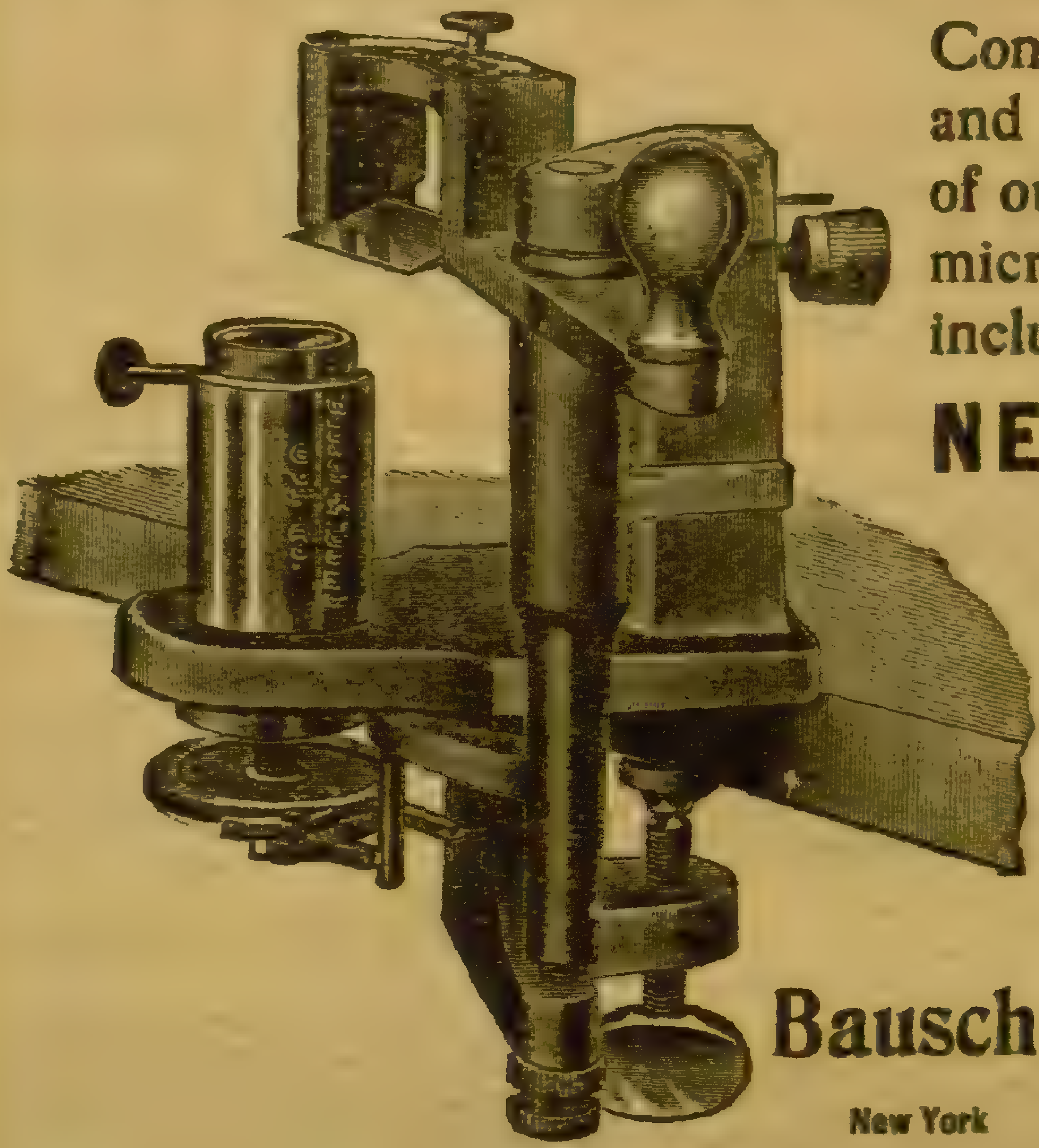

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THE AMERICAN NATURALIST

A MONTHLY JOURNAL
DEVOTED TO THE NATURAL SCIENCES
IN THEIR WIDEST SENSE

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A REMARKABLE OCCURRENCE OF THE FLY, BIBIO FRATERNUS LOEW.

JAMES G. NEEDHAM.

NOT far from my home in Lake Forest there is a forty-acre patch of woodland pasture that has been enclosed but not grazed for a number of years. It has become well overgrown with a thick blue-grass sod. Save for a few young hawthorns in scattered clumps, there is no underbrush. The open wood consists mainly of white oaks. Black oaks were originally abundant but have been cut down, and now the sod is thickly dotted with their rotting stumps. Around the bases of these stumps, where the sod closely enwraps them, is the larval home of *Bibio fraternus*.

I had seen but few specimens of this fly until the spring of 1901, and was wholly unacquainted with its immature stages and with its larval habitat. It chanced that on walking across this pasture in April I kicked over a rotten stump, and, where a lateral root pulled out from under the sod, there in the fine black soil that had resulted from the complete decomposition of the bark were a large number of dipterous larvæ, which later, when reared, yielded imagoes of this species.

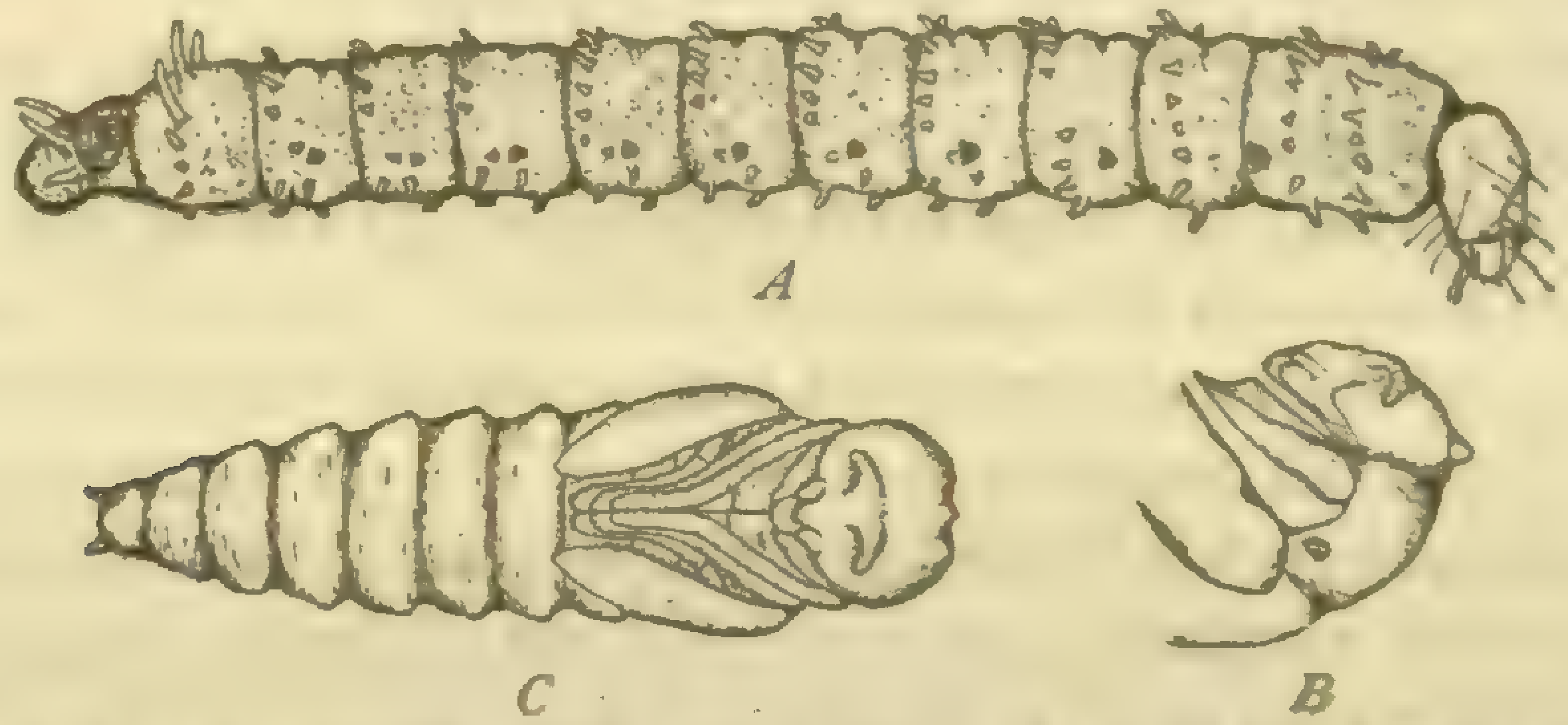
Nothing appears to have been written of the species since Loew penned the original description. In fact, the immature stages seem not to have been described or figured for any American species of the family Bibionidæ. Mr. D. W. Coquillett, who determined my imagoes for me, having assured me that under the existing circumstances even a slight contribution to the knowledge of these things would be welcomed by dipterologists, I offer herewith some observations on the habits of this species and a description of its immature stages.

Habits. — My acquaintance with the habits of the species began as indicated above. On May 5 I collected a large number of grown larvæ and a few pupæ about different stumps and placed them, with a quantity of their native soil, in a breeding cage. Imagoes began to appear on the 13th and continued transforming until the 20th. On the 18th, when my cage was full of fresh imagoes, I went out to the pasture but could find none there. In the earth were plenty of pupæ, but no more larvæ. Perhaps the development of those in my cage was hastened by the higher temperature of the laboratory in which they were kept. About May 22 the first few imagoes were observed at large. On the 24th I discovered, on walking across the pasture, that the grass was full of them. A score could be swept up at each stroke of the net; but none were flying, for the air was chill. On the 26th, 28th, and 30th, visiting the pasture again I saw the great swarms of them which I now come to describe.

I was not prepared for any exhibition of aërial activity by what I had seen in my breeding cage. There the imagoes seemed hardly able to walk, to say nothing of flying. They were very sluggish ; they climbed the sides of the cage weakly, and tumbled about even in walking, and were handled without any thought of their getting away. Even in the field on the 24th I had picked them up with my fingers and examined them unconfined under a lens. But on these three later days warm sunshine had stirred them to unexpected activity. They were flying in countless numbers in the more sheltered places in the woods and were actively climbing about in the branches of the opening blue-grass panicles or resting in pairs on the

leaves. The flight of the males is long sustained. Both males and females, and especially the latter, have some difficulty in getting launched. They climb to a leaf top, balance carefully, stretch their wings and try them before letting go, and finally swing free into the air.

I have rarely come upon a scene of greater animation than a sheltered hollow in this wood presented. There was the undulating field, clad in waving grass and set about with the pale-hued springtime foliage of the white oaks; there were the flowering hawthorns; and there were the myriads of Bibios floating in the sunshine, streaming here and there like chaff before sudden gusts and swirls of air. All the spiders' webs



A, larva of *Bibio fraternus* Loew., lateral view. *B*, lateral view of head of female pupa. *C*, ventral view of male pupa.

in the bushes were filled with captives; little groups of ants were dragging single flies away to their nests, and once I saw overhead a chestnut-sided warbler, perched on a bare bough directly in a stream of passing flies, rapidly pecking to right and to left, persistently stuffing his already rotund maw.

I stood in one spot and swept the air with my net for half a minute and obtained 128 male Bibios and 5 females: ratio, 25 : 1. I swept the grass a few times with my net and thus obtained 127 males and 372 females: ratio, 1 : 2.2. The discrepancy of ratios is due to the fact that a comparatively small proportion of the flies were in the air. I counted a number of flies I could see resting on the grass in several small areas wide apart and found the counts averaged 15 Bibios per square foot; and there were here in one place forty acres of such Bibio territory.[1] There can

[1] Professor Herbert Osborn notes the occurrence of *Bibio albipennis* in phenomenal numbers in Iowa, in *Insect Life*, vol. iii (1891), p. 479.

be no doubt that this obscure and little-known fly is a factor of considerable importance in the ecology of such a situation.

Immature Stages. — I now describe the larva and the pupa, and accompany the descriptions with drawings by Miss Maude H. Anthony.

Larva. — Length 13–14 mm.; diameter 1.5 mm. Body cylindric as far as the 9th abdominal segment, or with slightly greater depth in the thorax; head well developed, exserted, about equal in length to the body segments, except the first, which is a third longer than the others; there is a distinct Y-shaped suture on the top of the head; a pair of setæ are inserted just before and another pair just behind the clypeal suture; eyes wanting; four setæ on the epicranium each side, — two at the edge and one above and one below; there are lesser setæ on the maxillæ externally. The laciniæ of the maxillæ and the mandibles are elongate pyramidal, with low teeth on their truncated apices. There are two pairs of thoracic and eight pairs of abdominal spiracles: the foremost is situated at the rear of the prothorax and is larger than those following, except the last; the second pair is at the front margin of the metathorax; the next seven pairs are just before the middle of abdominal segments 1–7; those of the 9th abdominal segment are very large and each is divided by a median groove. Each of the middle body segments is completely encircled by a row of about a dozen tubercles, which is slightly oblique upon the sides and in which the dorsal tubercles are usually longer than the ventral, and there are a few tubercles out of line at the sides in the vicinity of the spiracle; on the 1st segment behind the head there is another row of eight tubercles, on the dorsum between the spiracles, and on this segment the tubercles are all longest at the sides; on segment 8 of the abdomen the dorsal tubercles are more elongate and the ventral ones more reduced; segment 9 is depressed conic, tapering posteriorly, with the large spiracles inserted in anterior emarginations of a brownish, chitinous, saddle-shaped plate, which covers most of the dorsum of the segment; behind this plate arise two pairs of filaments (elongate tubercles), the median pair as long as the segment is thick, the external pair a third shorter.

Skin granulate, closely invested with adherent dirt particles.

Pupa. — Length 7.5 mm.; breadth of thorax 2.1 mm., of abdomen 1.5 mm. Body smooth, whitish, with low appressed head, short, thick thorax, and straight abdomen whose sides are parallel except at its abruptly tapering apex.

Head flat, with short antenna cases which extend hardly more than halfway across the eyes, with well-marked paired jaw cases, and with an ocellar tubercle at the rear of the head above, low in the male, high and prominent in the female (owing to slight development of the compound eyes).

Prothoracic spiracles low, not elevated above the thoracic dorsum; no respiratory horns or trumpets.

Ninth abdominal segment terminating on the dorsal side in a pair of stout divergent triangular processes, that are about as long as the segment which bears them.

The rather generalized larva is characterized by an unusually well-developed head, simple mouth parts, rings of tubercles on all the segments, those of the two hindmost segments elongate, becoming filaments, showing out of what material the borders of the tipulid caudal respiratory disk have been made. The pupa is characterized by the unusual brevity of the antenna cases, which reach but halfway across the eyes, distinctly paired jaws, low prothoracic spiracles without respiratory trumpets, horns, or tubes, and a naked, spineless skin.

AN UNUSUAL OCCURRENCE OF DINOFLAGELLATA ON THE CALIFORNIA COAST.

HARRY BEAL TORREY.

Discolorations of the sea due to the presence of minute organisms, and often many miles in extent, have been seen in various parts of the world, along the shore and in the open sea. Deep-water sailors are familiar with such appearances, which they call "whale food," or "brim." The cause of the color is not always the same organism, though perhaps most frequently some species of Dinoflagellata, in enormous numbers.

This phenomenon was observed at San Pedro, Cal., during the present summer, and, according to the testimony of old residents, for the first time in that region. Something of the sort is said to have been noticed in Tomales Bay, some five hundred miles farther northward, in the early seventies. These are, I believe, the only known instances of its occurrence on the California coast; so that its rarity alone seems to demand a recording of the few notes taken during this last appearance.

It was first noticed on July 7 as a red streak off the mouth of San Pedro Harbor. During the next few days it approached the shore, changing its shape and dividing into several patches, each many acres in extent. On the 16th it reached the shore, and was the cause of a most unusual display of phosphorescence, which reappeared many evenings in succession. The phosphorescent water was found to contain vast numbers of a peridinian which I have referred tentatively to the genus Gonyaulax (see description below), and which gave it its red color during the day. Under the microscope Gonyaulax responded with a flash of light to any marked disturbance of the water containing it. At this time Noctiluca, so abundant later on, was not noticed. Wherever the ocean waters were roughened the wavelets were crested with green-blue light. In the quiet waters of the harbor the fishes, pelagic worms, and crustaceans traced trails of fire.

On the 20th, four days after the red (characteristically a muddy vermilion) streak had reached the shore, a most sickening odor arose from the water along the beach. On the 21st it was almost unbearable. During the night, on a beach about four hundred feet long, a large number of animals were left by the tide. Among them were several hundred holothurians (*Trachostoma arenata*), several specimens of two species of sting ray (*Mylobatis californicus* and *Urolophus halleri*), two species of guitar fishes (*Rhinobatus productus*, 3 individuals; *Platyrhinoidis triseriatus*, 3 individuals), two cestracionts (*Gyropleurodus francisci*), two dogfishes (*Galeus californicus*), a red perch, a large number of smelts, and several octopi. The fishes and octopi were dead, but many of the Trachostoma lived for several days. Many *Pinnixa faba* had crawled out of the cloacæ of the holothurians, on which they are normally parasitic.

On the 22d more Trachostoma were left on the beach. Some days later the odor had almost disappeared, but the water in the harbor and along the beaches was a brilliant vermilion. It was at this time that on two succeeding mornings a number of specimens of the blindfish (*Typhlogobius californicus*) were thrown up, both alive and dead. Then for two days came a number of *Tevila crassatelloidis*, many *Petrolisthes cinctipes* and *Cancer antennarius*. Finally, great numbers of *Hippa analoga* were thrown up, most of them alive but apparently debilitated and unable to dig as is their habit. They were mostly of large size.

This wholesale destruction was entirely unprecedented for the summer. The height of the tide and breakers were but subordinate causes at best; for, although the holothurians and selachians appeared after a higher tide and stronger sea than usual, as many of the former came up on a beach protected by a breakwater as on the beach shown in the photograph (Fig. 1). And as the tide fell from day to day, the animals did not cease to appear. The Typhlogobius appeared when the tide was moderate, with practically no sea running. This is interesting, not only because Typhlogobius usually lives, undisturbed by breakers, in holes and crannies among the rocks, which must

have been in this instance some distance from the beach, but also because it has never before been reported from San Pedro. The Gonyaulax served here as a means of discovery.

The above facts have been enumerated because they exhibit in a striking way a natural cause in process of eliminating the unfit of several and diverse species, which are resisting with various degrees of persistence and success. Whether this elimination is promiscuous, or correlated with variation from the type

Fig. 1. — Beach covered with dead animals, mainly holothurians with several selachians in the foreground; a result of the appearance of Gonyaulax.

of the species, is a question for whose solution material has been collected by Dr. F. W. Bancroft of this laboratory.

The "red water" occurred for two hundred miles at least along the coast, from the region of Santa Barbara to San Diego, and extended several miles to sea. It was still present around San Pedro on September 1. Wherever it was seen the fishermen reported a scarcity of food fishes. The small harbor fishes seemed to be unaffected by it, and the tiny invertebrates of the plankton were abundant in it. Noctiluca appeared in great numbers toward the end of July, and devoured Gonyaulax with

avidity. There were more copepods in the red streaks than in the intervening bluer water. I was not able to see any Gonyaulax in them, however.

Gonyaulax undoubtedly produced its harmful effects by dying in enormous numbers, the putrefactive changes thus occasioned polluting the water and giving rise to the stench already mentioned. It died most rapidly along the water's edge, thus affecting the littoral animals especially.

When placed under the microscope for examination in a drop of water, many Gonyaulax soon became quiescent, and the protoplasm drew away from the cuirass, forming a spherical cyst, which was often discharged by a rupture of the cuirass along any sutural line. Others died outright and disintegrated, leaving only the transparent, colorless cuirass. This tendency to die readily was noted long ago by Darwin for a species of dinoflagellate found in swarms off the western coast of South America.

With this enormously abundant species other species of Dinoflagellata were found: *Ceratium furca*, *C. fusus*, *C. michaelis*, *Peridinium divergens*, *Prorocentrum micans*, Polykrikos *sp.*, Dinophysis *sp.*, Noctiluca *sp.*, and certain swarmspores resembling those of *Peridinium ovatum*. The most abundant of these was Noctiluca, toward the end of July, but it did not begin to approach Gonyaulax in numbers. Where there was one Noctiluca there were hundreds, if not thousands, of the other form. The latter was present in the tow as early as June 17, in company with, and about as abundant as, the above-named species. All of these species increased during July, but Gonyaulax outstripped the others remarkably. The cause of this increase of one species over these closely related and associated species is not clear. I did not see a single case of fission, but the individuals varied so greatly in size as to suggest rapid reproduction, probably by encystment and spore formation, though no spores excepting the large Peridinium (?) swarmspores were seen. Noctiluca was sporulating at this time. It is possible that the immense patches of Gonyaulax were brought in by currents from deep water. Nothing, however, was seen of them throughout the season around Santa Catalina Island,

some twenty miles to sea. And if this were so, the cause of the rapid reproduction would still remain obscure.

The boundaries of the red streaks were quite sharply marked, although the water between streaks often contained Gonyaulax in abundance. Temperatures and determinations of salinity were taken at the surface and at the bottom of both red streaks and water entirely free of Gonyaulax. The readings averaged the same in all cases for the same depths. Soundings with a rather crude water bucket indicated that Gonyaulax was present approximately in as great abundance at the bottom at the depth of six fathoms as at the surface.

The key to the problem lies, I believe, in the chemical constitution of the water, since, aside from a sensitiveness to chemical

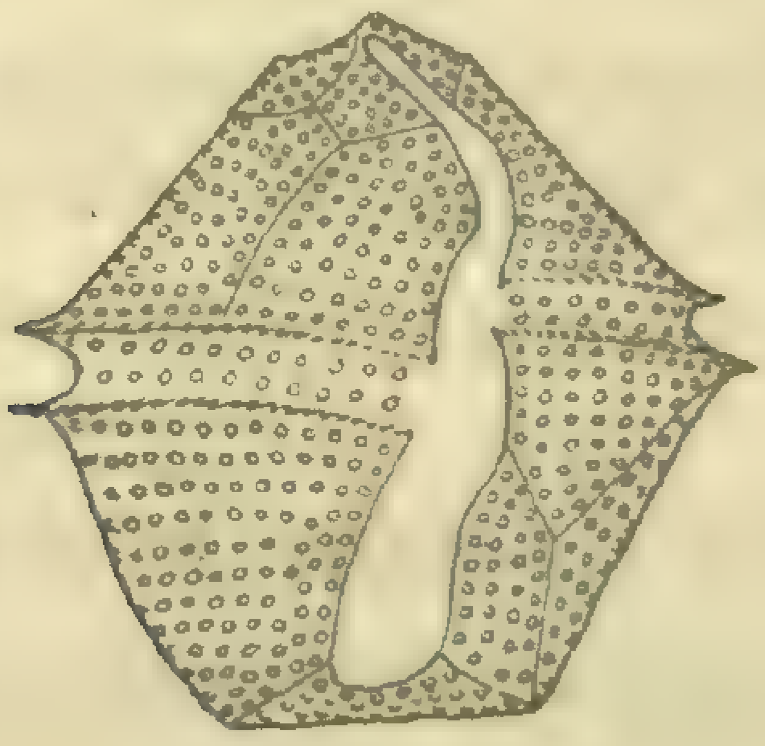


Fig. 2.

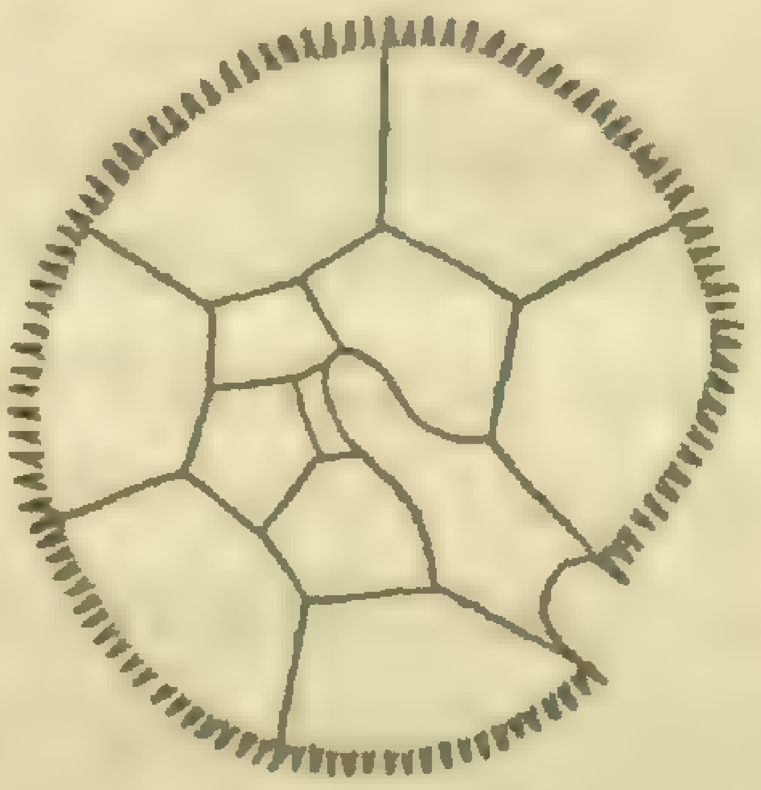


Fig. 3.

Fig. 2. — Gonyaulax, showing both longitudinal and transverse furrows.
Fig. 3. — Gonyaulax from upper pole, showing arrangement of anterior plates.

stimuli which it possesses in common with all living things, Gonyaulax is holophytic, if its color is a safe criterion. Zumstein has recently shown that the chlorophyll-bearing Euglena may lose its color under appropriate conditions and change its method of feeding in consequence to the saprophytic type. The *C. michaelis* and Polykrikos *sp.*, as well as the Peridium (?) swarmspore, found with Gonyaulax, were colorless. Not only, then, within the limits of one family of protophytes do two methods of nutrition exist, but in a single species, and possibly in a single life cycle. But the question of the source of the food of marine organisms is too vast a subject to be attacked with the scanty materials at hand. Whether Gonyaulax is nourished by inorganic or organic solutions, and whether a variation in food supply is the explanation for its unusual abundance, are problems to be solved by future experiment.

I have called the dinoflagellate with which these notes are chiefly concerned Gonyaulax, because in the first place it approaches that genus very closely, and in the second place such a small amount of the literature of the group is accessible to me that I do not feel warranted in erecting a new genus for it. It differs from Gonyaulax as described in Engler and Prantl's *Die natürliche Pflanzenfamilien* only in that in the anterior moiety of the cuirass there are six intermediate plates instead of five, and four end plates instead of three.[1] It may be described as follows (Figs. 2, 3):

Body divided by the equatorial furrow into two subequal halves, each of which is a low cone, the posterior one truncated. Anterior cone formed by six large intermediate plates meeting four much smaller unequal end plates in an angle somewhat less than one hundred and eighty degrees. Posterior cone of five large intermediate and one large end plate, with a narrow accessory plate next the longitudinal furrow. Equatorial furrow slightly oblique, deep, with toothed edges. Longitudinal furrow broader posteriorly than anteriorly, extending from the edge of the posterior end plate to the apex of anterior cone. All plates regularly bossed. Sutural lines raised into high, narrow ridges.

The equatorial flagellum alone is active in ordinary swimming, producing a rapid rotary and forward movement. The other, which trails behind during such progress, is responsible for the spasmodic jerkings occasionally seen.

The size of the cuirass varies from 25 μ in diameter by 29 μ in length, to 53 μ by 56 μ. Cysts average 24 μ in diameter. They are almost spherical, with granular contents of a brown-green color. Cuirass itself colorless.

Zoölogical Laboratory, University of California,
September, 1901.

[1] Since the manuscript was sent to press I have found that Bütschli (Bronn's Klassen und Ordnungen) has noted a similar discrepancy between the original description of Gonyaulax and his own observations, which leads me to suspect that the genus was wrongly defined by its author.

REGENERATION IN HYDRACTINIA AND PODOCORYNE.

ANNAH PUTNAM HAZEN.

In a paper entitled "Experiments in Regeneration and in grafting of Hydrozoa," [1] Peebles has given the results of some interesting experiments with Hydractinia and Podocoryne. These two hydroids are found at Woods Hole on the shells inhabited by hermit crabs. Each colony consists of three different kinds of individuals, namely, the nutritive, the reproductive, and the protective (a low cone-shape growth extending over the hydrorhiza is considered by some authors to constitute a fourth class of individuals). The experiments described by Peebles were confined to the first three classes. The well-marked characteristics of the different kinds of individuals make it possible to distinguish between them even when the polyps are immature or incompletely regenerated. The knoblike tentacles of the reproductive polyps appear during regeneration earlier than the reproductive organs, and the long, slender tentacles of the nutritive polyps can be easily distinguished from those of the protective individuals, which contain nematocysts. Peebles found that polyps freed from the hydrorhiza would live for days in small dishes containing sea water and quickly regenerate lost parts. Pieces of the stalk of these three classes of polyps, from which the heads had been cut, regenerated new heads of the same kind as those that had been removed. Small pieces cut at different levels from the stock of nutritive and protective polyps regenerated at one end a head like the one removed. Not infrequently a head appeared at both ends of a short piece. Without exception, the regenerated heads had the same characteristics as those that had been removed, and no constant variation in time or capacity for regeneration at the different levels was observed.

[1] *Archiv für Entwickelungsmechanik der Organism*, Bd. x, Hefte 2, 3.

Nutritive polyps cut from the hydrorhiza were grafted by Peebles in pairs, either by their oral ends (after removing both heads) or at the aboral ends (with both heads attached), or the aboral end of one individual was grafted to the oral end of another, from which the head had been removed. In all cases the line of union between the two components was soon effaced, the digestive cavities became continuous, and a complete union seemed to be effected. In all the experiments in grafting nutritive polyps, nutritive heads were regenerated at one or at both ends, and often also in the region of the graft. The union of different kinds of individuals was also successfully accomplished as follows: The aboral end of a nutritive polyp was grafted to the aboral end of a protective polyp,—the direction of the two components being thus reversed. After a few hours the nutritive head was removed, leaving a portion of its stalk attached to the aboral end of the protective polyp. The head which regenerated at the free cut surface showed markedly the characteristics of the nutritive individual and did not seem to be in the least affected by union with the protective polyp. Similar grafts were made with nutritive and reproductive polyps, followed by a removal of the reproductive head. Here, again, the regeneration of a reproductive head at the end of the stalk showed no modification due to the union with a nutritive polyp.

The results of these experiments by Peebles suggested the following questions: first, Would the fixation by means of stolons of one of the components of the graft alter the result? second, Would the kind of regeneration that took place be affected by the relative orientation (with respect to the polarity) of the pieces? With these questions in mind, I carried out the following series of experiments at the Marine Biological Laboratory during a few weeks in July and August, 1901.

Both Hydractinia and Podocoryne were used, and the method of grafting was similar to that employed by Peebles. It was found to be of importance to use fresh material, since that kept for several days in the aquarium regenerated more slowly and less constantly than material just brought in. A few experiments like those described by Peebles were repeated

and similar results obtained, although most of the grafts were made by joining the aboral end of a reproductive polyp to the oral end of a nutritive stalk, the head of the latter having been previously removed. In this way the direction of the two components was the same, instead of reversed, as in Peebles's experiments. The pieces were allowed to remain undisturbed for a short time after grafting, or until the tissues had become united, so that the reproductive head could be cut off without danger of separating the grafted pieces. Better results seemed to be obtained if the head were removed within a few hours after union, so that the process of regeneration started in the first night after the graft had been made, although satisfactory results were sometimes obtained when the cut was made on the second day. Fig. 1 represents a typical experiment of this kind. An immature reproductive polyp (*r.*) was selected and grafted at its aboral end to the oral end of a nutritive stalk (*n.*) from which the head had been removed. The tissues joined, and a few hours later the reproductive head was removed, leaving the two components of nearly equal size. Within twenty-four hours a complete reproductive head had regenerated (*rh.*), which showed no modification due to the influence of the stalk of the nutritive polyp.

FIG. 1. — × 45. The aboral end of an immature reproductive polyp (*r.*) was grafted to the oral end of a nutritive stalk (*n.*) August 3. A few hours after the union, the reproductive head was cut off, as indicated by the dotted line. The next day a reproductive head (*rh.*) had regenerated on the end of the reproductive stalk. (Drawn August 5.) The arrows point toward the oral end of each individual.

When the union of the two components was incomplete and a part of the cut surface of the nutritive stalk was exposed at the side, tentacles or a whole nutritive head developed at this place, as shown in Figs. 2, 3, and 4, *nt.* This occurred frequently, as the nutritive polyps are often much larger than the reproductive polyps, and the latter, unable to cover the whole cut surface, unite with the nutritive only at one side. This did not prevent the body cavities of the two components from becoming continuous. The portion of the reproductive stalk (*r.*) used in the experiment shown in Fig. 2 was taken

from the oral region of a young individual, while the nutritive component (*n.*) came from the aboral region and shows a piece of a spine (*s.*) attached to its base. Although, in this case, the nutritive component was relatively much larger than the reproductive stalk, a head regenerated on the latter which showed no apparent influence of the larger component but possessed only the characteristics of the reproductive head.

FIG. 2. — × 45. The aboral end of a young reproductive polyp (*r.*) was grafted to one side of the oral end of a nutritive stalk (*n.*) August 3. A few hours later the reproductive head was cut off as indicated by the dotted line, leaving a small portion taken from the oral half of a reproductive individual attached. A reproductive head (*rh.*) regenerated at the end of the reproductive stalk and nutritive tentacles (*nt.*) around the end of the nutritive stalk. A piece of spine (*s.*) was attached to the base. (Drawn August 5.)

Another experiment is shown in Fig. 3 in which the nutritive stalk (*n.*) was many times larger than the small component taken from a reproductive polyp (*r.*). The latter was cut from the aboral region of an adult individual from which most of the generative buds had been removed.[1] Here, again, the union was complete, and again the regenerated head showed no effect produced by the larger component, but the new growth corresponded to what would probably have appeared on a reproductive stalk alone from which the head had been removed.

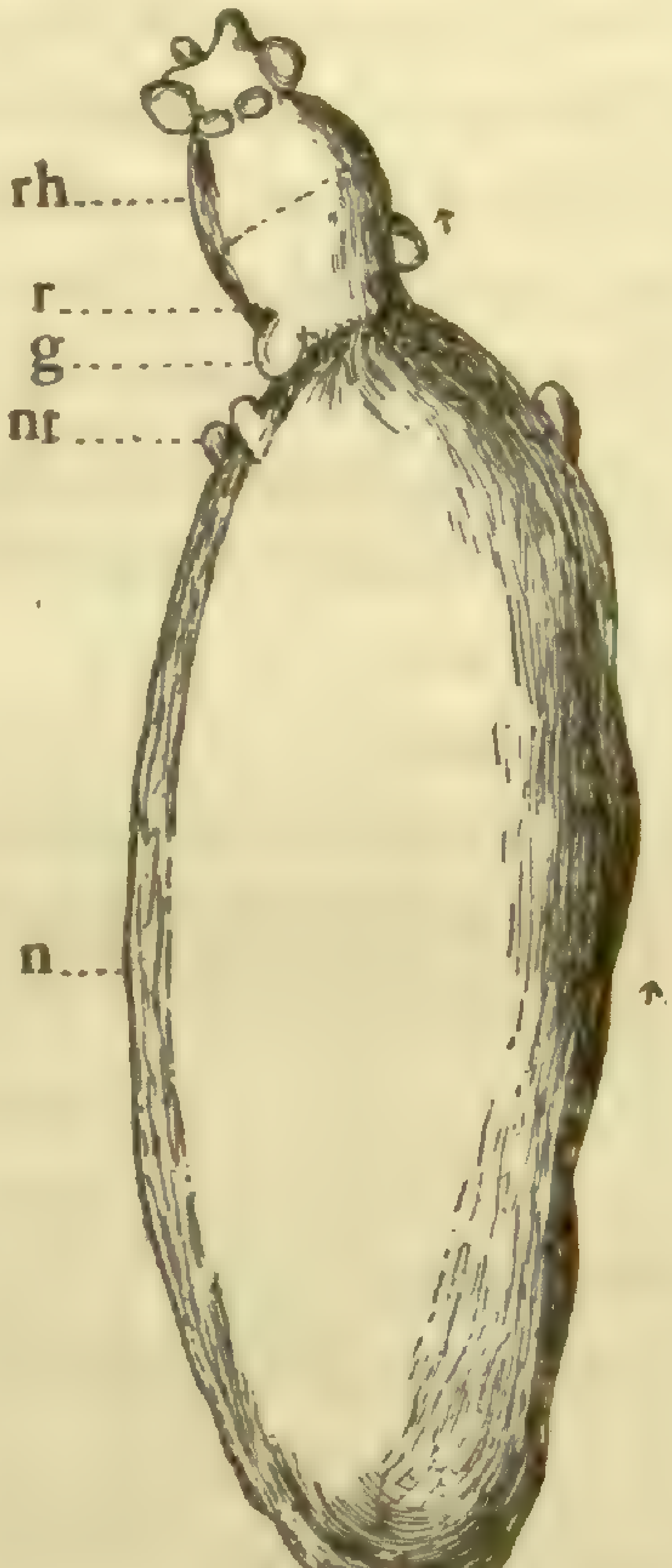


FIG. 3. — × 45. The aboral end of a reproductive polyp (*r.*) was grafted, July 25, to the oral end of a nutritive stalk (*n.*). Three hours later the reproductive head was removed at a place indicated by the dotted line. The reproductive component which remained was from the aboral region of an adult. Two generative buds (*g.*) were left attached; others had been removed. A reproductive head (*rh.*) and nutritive tentacles (*nt.*) developed. (Drawn July 27.)

Many similar experiments were made, from which these have been selected as typical. Considering that these different

[1] Two generative buds were left, as shown in Fig. 3, *g.*

individuals are organically connected, it seemed at the outset possible that, under certain conditions where a complete union was effected, the subsequent regeneration might be modified. This seemed especially likely to occur if the nutritive polyp, which is the more vigorous and the less specialized of the two, formed the larger component. Repeated attempts were made to leave as small a portion of the reproductive stalk as possible attached to the nutritive component, but, with one exception, none were obtained in which the regenerated head showed the influence of the nutritive polyp. The result is the same when the direction of the two components is reversed, as in Peebles's experiments, and when it is the same, as in most of my experiments (see Figs. 1, 2, and 3). All regions of the stalk from which the components are taken seem equally unable to influence the subsequent regeneration or to be influenced by the union. It was also found that the regeneration following a graft of this sort is no more easily influenced when the reproductive component is taken from an immature polyp than when it is taken from an adult.

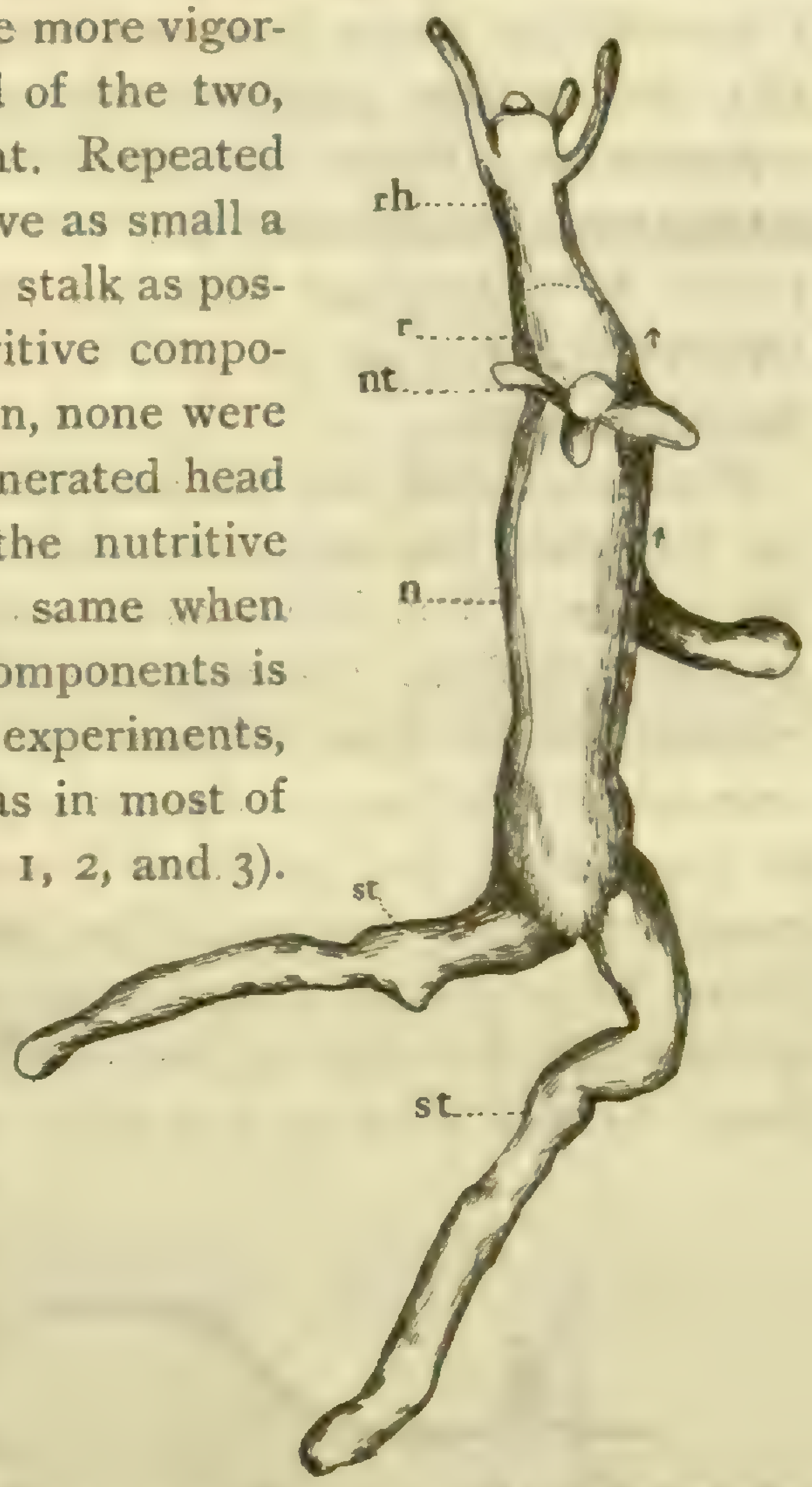


Fig. 4. — × 45. The aboral end of a reproductive polyp (*r.*) was grafted to the oral end of a nutritive stalk (*n.*) July 20. The reproductive head was cut off July 21, as indicated by the dotted line. The next day a nutritive head (*rh.*) had regenerated on the end of the reproductive stalk and nutritive tentacles (*nt.*) at the point of union between the two components. Stolons (*st.*) had also developed on the aboral end of the nutritive stalk attaching it to the disk. (Drawn July 23.)

An interesting and solitary exception to these results is illustrated in Fig. 4. A nutritive polyp (*n.*) and a reproductive polyp (*r.*) were grafted as in the preceding cases, and on the following day the reproductive head was removed, leaving only a small part of the reproductive stalk attached. A day

later a nutritive head (*rh.*) had regenerated on the end of the reproductive component and, at the same time, stolons (*st.*) had pushed out from the nutritive polyp, fastening it to the bottom of the dish. As this was the only instance in which a reproductive polyp produced a nutritive head, it was probable that a new condition had appeared and affected the regeneration. What this condition may have been was not satisfactorily determined, but a possible explanation was suggested by comparison with the results of another series of experiments carried on at the same time. These will be described below.

Peebles showed that pieces of the stalk of nutritive polyps cut free from the colony and allowed to remain undisturbed at the bottom of a shallow dish of water sometimes sent out long branching stolons, the original stalk becoming absorbed and indistinguishable from the newer growth. "After several days new individuals began to appear, growing up at right angles to the stolons, just as the different individuals of a colony grow from the hydrorhiza. The formation of new polyps continued for several weeks when the experiments were brought to an end. As many as ten to fifteen new polyps were produced by one piece of the stalk. These polyps were inva-

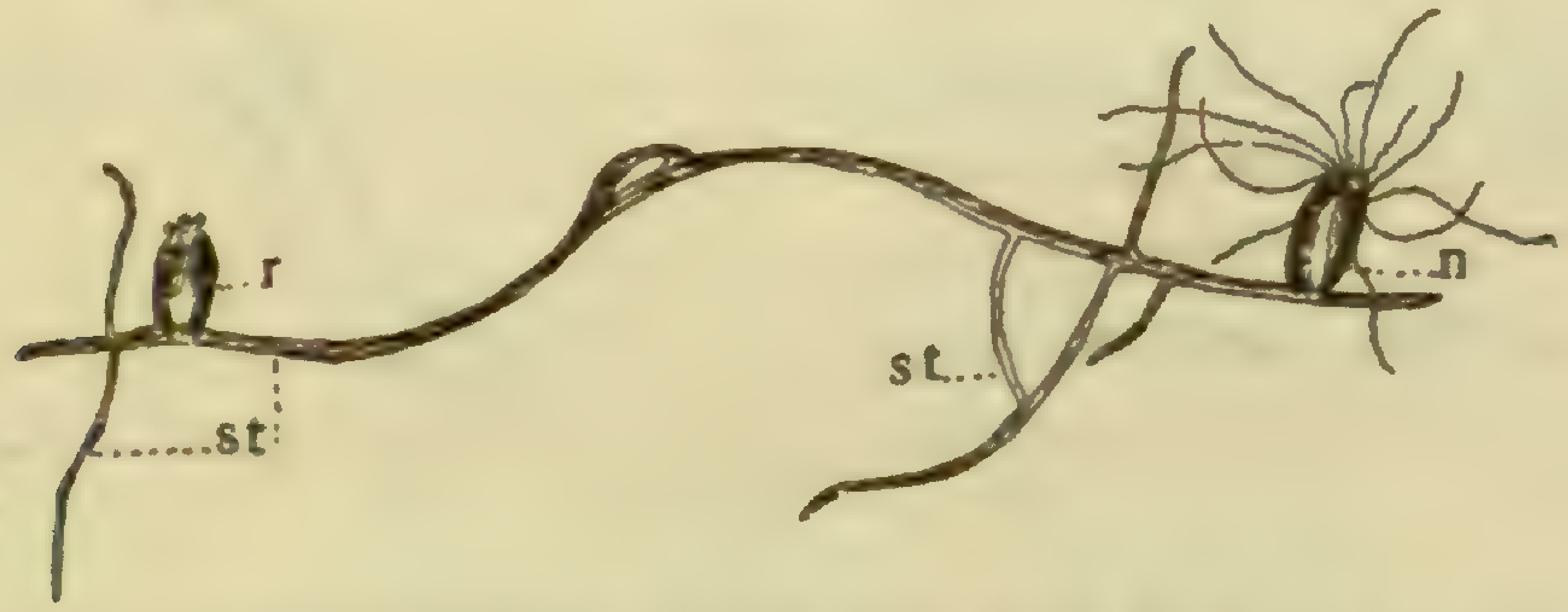


FIG. 5. — Represents a small portion of a colony which had developed from a nutritive polyp, showing a new nutritive polyp (*n.*), a reproductive polyp (*r.*), and stolons (*st.*). The original polyp had been absorbed. The colony was started July 24. The drawing was made August 3. The disintegration of the colony began August 8.

riably nutritive individuals, characterized by their long slender tentacles." I repeated this experiment and also used pieces of nutritive polyps as well as pieces of the stalk. The growth of a large number of colonies followed. New nutritive polyps were always the first to appear on the stolons,

but after the colony was well formed a few small reproductive polyps also grew out from the stolons at occasional intervals (Fig. 5). Although the colony lived for several days or a week after the production of the reproductive polyps, no signs of

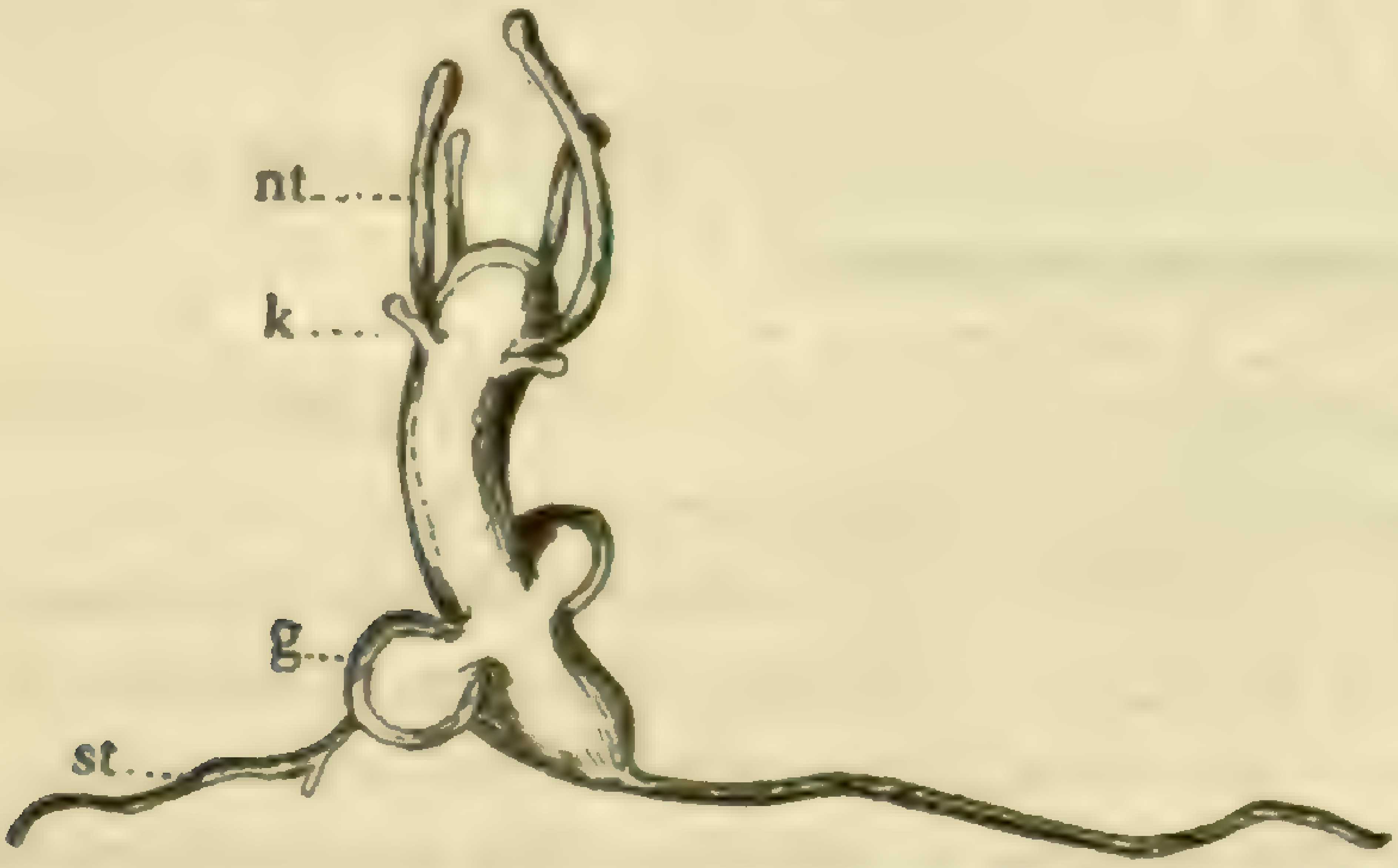


FIG. 6. — Represents a reproductive polyp which was cut from the hydrorhiza July 20. Several generative buds were removed; two were left (*g*.). The reproductive tentacles were replaced by four nutritive tentacles (*nt*.). Two small knoblike tentacles (*k*.) are seen below the nutritive tentacles. At the same time the nutritive tentacles were developing, stolons (*st*.) grew from the aboral end, fastening the individual to the disk. (Drawn July 23.)

developing generative buds appeared. Indeed, the life of the colony seemed spent, the stolons became more slender and broke apart, and the polyps died, one after another. During the period of growth the stolons often anastomose and two adjacent colonies become united. Such colonies are most easily started if whole polyps are cut off close to the hydrorhiza. A small piece of a polyp will lie on its side on the bottom of the dish, often producing new hydranths and changing its form, until it disintegrates, but rarely forms stolons.

In the same way reproductive polyps were removed and kept in dishes, with the hope that they would also form colonies. They sent out stolons much more slowly than the nutritive polyps did, and although a large number of individuals formed stolons, many of them died before new polyps had developed. It is probable that others, which seemed more vigorous, might have developed new polyps had more time been allowed them. In one dish in which half a dozen reproductive polyps had formed stolons a curious change was observed. The stolons had grown rapidly, and the hydranths

which had borne the small knob characteristic of the reproductive polyp showed, in three days, a remarkable development of tentacles like those on a nutritive hydranth, as shown by *nt.*, Fig. 6. Two small knobs (*k.*) are present below the ring of tentacles, and these may — or may not — represent those of the original reproductive hydranth. A few large generative buds had been removed from the polyp, but two remained as seen in Fig. 6, *g.* The polyps seemed vigorous, but possibly the presence of the generative buds caused an early disintegration. At all events, they all died before any new polyps were formed by the stolons. What the condition was which brought about this change was not determined, but it seemed possible that the formation of stolons might be connected with the development of nutritive tentacles. The growth of stolons in this case (Fig. 6) was more rapid than in that of other reproductive individuals in which the nutritive tentacles did not develop. In other instances the reproductive heads may have lost the power of developing the long tentacles when the stolons were late in appearing. A clearing up of this point might throw light on the experiment described above (Fig. 4), in which a piece of a reproductive stalk grafted to a nutritive polyp regenerated a nutritive head. The reproductive head had not been removed until the day following the graft, and the stolons developed at the same time that the head was regenerated. The regeneration of the nutritive head might have been influenced by the developing stolons.

It gives me pleasure to acknowledge my indebtedness to Prof. T. H. Morgan for many suggestions during the course of this work.

Smith College,
Northampton, Massachusetts.

ON THE STANDING OF PTEROPUS HALDEMANI HALOWELL.

JAMES A. G. REHN.

In 1846 Halowell described a species of Pteropus from West Africa as *P. haldemani* (*Proc. Acad. Nat. Sci. Phila.*, Vol. III, p. 52); this species has generally been overlooked. Several years ago Mr. Paul Matschie of the Berlin Museum für Naturkunde resurrected the species (*Sitzungs-Bericht der Gesellschaft naturforschender Freunde zu Berlin*, 1899, Nr. 2, p. 30) and made the rather startling assertion that it was based on a young example of *Hypsignathus monstrosus* H. Allen (*Proc. Acad. Nat. Sci. Phila.*, 1861, p. 156). In his recent monographic work (*Die Megachiroptera des Berliner Museum für Naturkunde*, p. 42) Mr. Matschie repeats his previous views. As Mr. Matschie did not examine the types of either *P. haldemani* or *H. monstrosus*, his conclusions were formed entirely from a description which gave no idea of the cranial or palatal characters.

The types of both species are contained in the collection of the Academy of Natural Sciences of Philadelphia, and on examination the writer finds that Mr. Matschie's conclusions are not sustained by the specimens.

The type of *Pteropus haldemani* consists of an alcoholic skin from which the skull had never been detached, and on removal the latter is found to be quite typical of the genus Epomophorus, and in no way closely related to Hypsignathus. The molars are low and slightly grooved as in Epomophorus and lack the lateral cusps characteristic of Hypsignathus. The skull and the external aspect of the head exhibit no trace of the extraordinary club-like development observed in the last-mentioned genus, which would surely be appreciable even in a young individual.

The structure of the palate agrees exactly with *Epomophorus gambianus* Ogilby (*Proc. Zoöl. Soc. London*, 1835, p. 100) as

figured by Dobson (*Catalogue Chiropt. Brit. Mus.*, Plate II, Fig. 3, *a*), and *Pteropus haldemani* can, without hesitancy, be considered synonymous with Ogilby's species.

ACADEMY OF NATURAL SCIENCES,
PHILADELPHIA, PA.

THE COLORS OF NORTHERN POLYPETALOUS FLOWERS.[1]

JOHN H. LOVELL.

According to the later systems of classification the Apetalæ and Polypetalæ form a single subclass, the Choripetalæ. In the apetalous families of eastern North America, which have been considered in an earlier paper, there are 175 green, 89 white, 51 yellow, 45 red, and 24 purple flowers. The 1217 polypetalous plants have 140 green, 410 white, 333 yellow, 84 red, 193 purple, and 57 blue flowers. The northern Choripetalæ, then, contain 315 green, 499 white, 384 yellow, 129 red, 217 purple, and 57 blue flowers. Of the 92 families belonging to the Choripetalæ, 47 contain green, 52 white, 45 yellow, 28 red, 39 purple, and 5 blue flowers. The much greater abundance of species and families with green, white, and yellow coloration, as well as the less specialized structure of the flowers, points to these colors as more primitive or more easily developed than red, bright purple, or blue. In certain genera, however, small dull red and purplish flowers are evidently derived directly from the primitive green.

The order Ranales includes the Nymphæaceæ, Magnoliaceæ, Ranunculaceæ, and six other families of less importance. The simpler species of this order have the organs of the flowers spirally arranged, separate and distinct, and the stamens and pistils indefinite in number, as in Ranunculus. From the dominating character of the Ranales, says Engler, it is clear that the other orders of this series diverge from the Ranales in various ways, some following one direction of development, some another. The ancestral form of the angiospermous flower would appear to have been a branch, or part of a branch, with carpophylls at the end, followed by androphylls, and then by the primitive

[1] The Colors of Northern Monocotyledonous Flowers, *Amer. Nat.*, vol. xxxiii, p. 493; The Colors of Northern Apetalous Flowers, *Amer. Nat.*, vol. xxxv, p. 197.

leaves destined to form petals, sepals, and bracts. No such inflorescence now exists, but an approach to it may be found in the Magnoliaceæ. In Magnolia the floral bud terminates the secondary branches, of which it is only a prolongation. The oblong flower of the Magnolia has the receptacle prolonged and the parts of the perianth, the stamens, and the pistils, spirally arranged and indefinite in number. In the arrangement of the plant families in a lineal series, those flowers which have the organs separate and which resemble most closely the proangiospermous floral branch are regarded as the simplest; while the highest rank is assigned to those which have the organs modified and consolidated, as in the Orchidaceæ and Compositæ.

In the Nymphæaceæ, or water lilies, we meet with dicotyledonous plants resembling monocotyledons in the structure of the leaf and rootstock. The analogous arrangement of the fibrovascular bundles in a Nymphæa and a Tradescantia has been excellently figured by De Bary. The successive steps in which simple and distinct carpels may become compounded are also well shown by the genera of this family. In the primitive genus Nelumbium, also in the oldest forms found in a fossil condition, the simple carpels are contained in little pits in the large fleshy receptacle; in Cabomba and Brasenia the oblong carpels are borne on the receptacle, but are separate; in the fossil genus Anœctomeria of the Middle Tertiary the carpels are partially united; in Nymphæa the union is complete; and finally, the culmination is reached in *Victoria regia*, where the compound ovary is inferior. Of the eleven northern species four are white, five yellow, one red, and one purple. Yellow coloring was probably very early developed, as it is the color of the primitive *Nelumbo lutea* and of the three native species of Nymphæa (Nuphar). Throughout the summer the numerous broad shining leaves and large yellow flowers of *Nymphæa advena*, the large yellow pond lily, form a well-known characteristic in the vegetation of ponds and slowly moving streams. The six sepals are unequal: the three inner are large and bright yellow; the three outer and smaller are wholly or partially green exteriorly, though the upper half is often yellow, while the interior lower portion is reddish purple. The numerous petals are thick, short,

truncate, wedge-shaped bodies, which serve as honey glands. The honey is freely secreted on the outer side near the top, the nectariferous portion being orange yellow. The fruit is scarlet. I have collected upon the flowers in Maine four Diptera, two Coleoptera, and one small bee, *Halictus nelumbonis*, which confines its visits to this flower. Great numbers of the small fly *Hilara atra* revel in the pollen. The single species of Cabomba is white with a yellow base, and the northern species of Castalia (pond lily) are pure white tinged with pink, or deep pink in a variety growing in eastern Massachusetts. In the famous *Victoria regia* of the Amazon the outer petals are white and the inner crimson, and in *Nymphæa cœrulea* of the Nile the flowers are blue. The leaves of several genera are strikingly bicolored, being light green above and violet or reddish purple below. According to Kerner the anthocyanin, or purple coloring matter on the lower side of the leaf, can arrest the rays of light (which would otherwise escape into the water) and change them into heat and make them useful to the plant.

The largest tree flowers known belong to Magnolia. "Their effect in early spring is grand beyond description, illuminating the whole landscape and filling the air with their rich perfume." The red flower of *M. campbellii* of Himalaya is ten to eleven inches broad, while *M. macrophylla* of the Southern States has flowers ten inches in diameter. Of the five species of the Magnolia four are white and one greenish yellow. *M. macrophylla* is white with a purple center, while *Liriodendron tulipifera*, tulip tree, is greenish yellow without and yellow within. *Magnolia grandiflora* is fertilized by rose beetles or Cetoniæ. At night the white flowers are 5° to 10° C. above the surrounding air, and thus afford warmth as well as food.

Both the Nymphæaceæ and Magnoliaceæ produce very large and conspicuous flowers, which are pollinated by the smaller bees, flies, and beetles. While these splendid showy flowers are, no doubt, of benefit for attracting the attention of insects, yet it is evident that they could be produced only by large trees and vigorous herbaceous plants. The water lilies grow in situations where the soil is charged with nitrogenous matter, and the framework of the plant requires a minimum of mechanical

support. The Magnolias are stately trees, growing in rich woodlands. Both families have very large leaves. The primitive color of the flowers was probably green, as it still is in *Magnolia acuminata*. Transition stages from green to yellow occur both in Liriodendron and in *Nymphæa advena*. In other instances, as in certain species of Magnolia and Castalia, they became white at a very early stage, and in certain species subsequently changed to red. In the case of *M. macrophylla*, where the white flower has a large purple center, the entire flower may have been purple, as in *Illicium floridanum*, or anise tree, or it may be a deposit of pigment resembling that found on the inner side of the sepals of *Nymphæa advena*.

In a part of the species of the Ranunculaceæ the petals are wanting; in a part they are small and transformed into hollow nectaries; while in others they are regular and conspicuous. The ancestral stock from which the various genera have diverged doubtless possessed petals, or phyllomes, corresponding to this whorl; but they had already been lost by some generic lines when insects began to visit the flowers. Of the ninety-seven species, six are green, twenty-six are white, thirty-eight are yellow, three are red, thirteen are purple, and eleven are blue. Conspicuousness is insured by the sepals in Clematis and Caltha; by the petals in Ranunculus; by both the petals and sepals in Aquilegia; and by the numerous stamens in Thalictrum, Actæa, and Cimicifuga. In Thalictrum the white or lilac filaments are broad and petaloid. The flowers are visited infrequently by flies and the short-tongued bees.

Of the apetalous flowers, *Caltha palustris* and *C. flabellifolia* have a yellow, and the aquatic *C. natans* a white, calyx. A change of locality may induce a change from yellow to white, as *Anemone alpina* on the Central Alps bears chiefly sulphur-yellow flowers, but in the eastern limestone Alps its flowers are always white. In our native species of Anemone the sepals are green, white, or purplish, but florists offer scarlet and blue varieties. The anthocyanin displayed by the underside of the sepals of *A. nemorosa*, especially in bud, probably serves to convert light rays into heat; this plant blooms in early springtime. The sepals of *Clematis ochroleuca* are green, of *C. virginiana*

white or greenish white; but in most species of Clematis the color is purple. By hybridization a great variety of hues have been produced, including blue, red, cream, and yellow. The calyx of Hepatica is white, rose, or blue. Kerner remarks that the flowers, which appear as soon as the snow leaves the ground in open woods, by their blue color present a strong contrast against the yellow-brown leafage, whereas in green meadows they would scarcely be seen. The occurrence of blue sepals is rare and is perhaps nowhere so well shown as in this family. From this brief survey of the coloring of the calyx it is evident that its capability for developing a wide range of colors equals that of the corolla. Though commonly green and only protective, it may give rise to any color.

In other genera of the Ranunculaceæ the petals are present but are transformed into nectaries. In Eranthis and Helleborus they take the form of a trumpet; in Isopyrum they are spoon-shaped, in Nigella lamp-shaped; in Coptis they resemble a hood, in Aquilegia a horn of plenty; and in Delphinium the two upper sepals and petals are both spurred. Tubular petals have also been observed in *Ranunculus repens* by Masters.[1] This tendency is inherent in the flowers and not induced by the agency of insects, and has greatly aided in the production of the different genera. The sepals of all these flowers are conspicuous. In *Helleborus viridis* the calyx is yellowish green, and in *H. niger*, or Christmas rose, which blooms in winter, the flowers are at first white, turning pinkish, and then green. *Trollius laxus*, which grows in the shade of dense swamps, has greenish-yellow flowers, while *T. europæus* has bright yellow sepals. *Coptis trifolia*, a woodland plant, has small white flowers in springtime.

The species formerly included in the genus Ranunculus, but now segregated into several genera, have the petals large and regular. The nectar is secreted in a little pit near the base. The thirty-one species of Ranunculus native in the northern states are yellow, or whitish in *R. nivalis*, or occasionally in *R. acris* in autumn. A wide range of colors is displayed by *R. asiaticus*, including yellow, red, purple, and nearly black.

[1] *Vegetable Teratology*, p. 23.

R. viridiflora is green, with scarlet edges. In *R. auricomus* the petals are sometimes wanting, and their place is taken by the sepals with their bright yellow limb. In *Ficaria ficaria* (*R. ficaria*) the petals are yellow, or red fading whitish. The white flowers of Batrachium, or water crowfoot, show that they are descended from ancestral yellow forms by retaining vestiges of this color as honey guides at the base of the petals. The cultivated *Adonis annua*, or pheasant's eye, has showy orange or red flowers, to which the black anthers offer a marked contrast. The most highly specialized regular flowers of this family belong to Aquilegia, or columbine. They may be regarded as the culmination of the buttercup type. The sepals are regular and petaloid, while the petals are prolonged backward into a hollow spur. The intermediate stages between the nectariferous pit of the buttercup and the hollow petal of Aquilegia are excellently shown in the extremely variable petals of *R. auricomus*. *Aquilegia canadensis* produces scarlet flowers, which are yellow inside and rarely all over, or occasionally they are white. There are two other species in the northern flora which exhibit a similar coloring, *Lonicera sempervirens* and *Spigelia marylandica*, and the former is sometimes yellow throughout. *A. canadensis* is visited by bumblebees and humming birds. The European *A. vulgaris* is blue, purple, or white.

The two zygomorphic genera, Delphinium and Aconitum, are the most recent in their origin, and represent the highest stage of development attained by the Ranunculaceæ. The sepals are petal-like. The flowers are blue or revert to white, or, in *Aconitum reclinatum*, are regularly white. High specialization, pollination by bees, and probably blue color, are here correlated. Masters gives an instance in *Delphinium peregrinum* of perfectly regular flowers having five sepals and five oblong stalked petals, and also in Aquilegia the tubular petals may be replaced by flat ones.

At the period when insects began to visit the flowers of the Ranunculaceæ, the different genera were in a transition state and only partially differentiated. It is evident that one effect of their visits was to render the flowers conspicuous. This result has been reached in different ways in the various genera, according

as the pigments have been deposited in the sepals, petals, or stamens. But while insects have been instrumental in developing bright coloration, the particular colors of the different species have been very largely determined by other conditions. The yellow of *Caltha palustris* and Ranunculus has probably been preceded by no other color than green. These flowers are visited by numerous flies, beetles, and the less specialized bees. Syrphidæ are abundant, a family of flies with many species, characterized by yellow markings, which would indicate that yellow was especially attractive to them. Müller states that he has seen *Eristalis intricarius* hover over the yellow flowers of Caltha, as the males hover over the females, then suddenly settle to suck honey or feed on the pollen. He also suggests that their love of yellow may have arisen from their visiting flowers of this color, and that sexual selection may have been guided by this taste. The white flowers of Batrachium have evidently passed through a yellow stage, but in other genera white or purple has been developed directly from the primitive green, as in Clematis. The blue flowers of Hepatica, Aquilegia, Delphinium, and Aconitum, which are very attractive to bees, appear to have passed through a yellow or white stage. The organs of the flowers of the Ranunculaceæ, according to Masters, more frequently revert to leaves than do those of any other family except the Rosaceæ.

The Berberidaceæ, Menispermaceæ, Calycanthaceæ, and Lauraceæ contain but few species. The shrubs of Berberis, or barberry, have the wood as well as the calyx and corolla yellow. The flowers are attractive to bees and flies. The foliage in autumn is yellow and crimson. The three white-flowered species of the Berberidaceæ occur in woodlands and bloom in May. The Menispermaceæ are woodland vines with small white flowers in panicles, or green in Calycocarpum, where the petals are wanting. The small flowers of the Lauraceæ are apetalous, but the calyx is yellow. The species are aromatic shrubs and trees.

The original color of the Papaveraceæ, or poppy family, was probably yellow. The sap also of many genera is yellow or red. The beautiful flowers of Papaver are yellow or scarlet, with a darker center. If the flowers contained nectar, this central

marking would be regarded as a honey guide, but as they are nectarless, and are visited by Andrenidæ and Diptera for pollen, it must have a different significance. It may be due to the more abundant nutrition received by the central portion. In the cultivated variety called Shirley the edges of the flower are white and the center is crimson. If a plant receive a check during growth by transplanting, the flower may revert to pure white. Such color contrasts, however, render the flowers more conspicuous. According to Kerner, honeybees do not visit scarlet flowers, either because they do not distinguish this color, or because it is unpleasant to them. In a garden in front of the house where he lived the scarlet geranium, *Pelargonium zonale*, and the narrow-leaved willow-herb, *Epilobium angustifolium*, were in bloom at the same time and not far apart. He observed that butterflies visited both indiscriminately; but the honeybee never paused in its flight over the scarlet flowers, though it frequently sought the red-purple flowers of the willow-herb. The flowers of Papaver are one to three inches broad, and hybrids are sometimes twelve inches in width. The flowers of Argemone, or prickly poppy, are also several inches in width. *A. mexicana* is yellow, rarely white, and *A. alba* is regularly white. *Sanguinea canadensis*, bloodroot, has a white flower and red sap; but the flower is sometimes pinkish, as is indicated by the name "red Indian paint." The genera Stylophorum, Glaucium, and Chelidonium have yellow sap and yellow flowers.

A group of irregular flowers formerly placed in a separate family, the Fumariaceæ, are now included in the poppy family. The species are fertilized by the long-tongued bees and flies. The heart-shaped pendulous flowers of Bicuculla (Dicentra), Dutchman's breeches, are white or pink. The smaller flowers of Capnoides (Corydalis) are pale yellow, while the larger are bright yellow. *C. sempervirens* is pink with yellow tips, and in bud is greenish white, while the European *C. solida* has the entire flower red. The influence exerted by insects upon the particular colors is very uncertain.

The Cruciferæ, like the Umbelliferæ, form a very natural family; the flowers closely resemble each other and differ chiefly, as Müller states, in the number and position of the honey glands

and in the situation of the anthers in relation to these and to the stigma. Many genera show evidences of retrogression in the small white flowers and in the regularity with which self-fertilization occurs. *Pringlea antiscorbutica*, which grows on the stormy shores of Kerguelen Land, where no winged insects can exist, since they would be swept into the sea, has reverted to wind-fertilization. In sheltered places the petals, which usually are wanting, are frequently present, and "on the same raceme some flowers may possess only a single petal, others two, three, or four; and the petals, though usually of a pale greenish color, are occasionally adorned with purple." This family is much less attractive to insects than the Umbelliferæ, and is visited chiefly by flies and the less specialized bees, such as Andrena and Halictus, and by a few beetles and Lepidoptera. Some flowers have no recorded visitors.

Of the 113 flowers, 2 are green, 54 white, 46 yellow, 1 red, and 10 purple; 20 of the 37 genera contain white and 16 yellow flowers, but only 4 genera contain both yellow and white. The white flowers are usually small, or even minute, and self-fertilized as in Subularia (awlwort), Lepidium (cress), and Bursa (shepherd's purse). The yellow flowers are larger, as in Sinapis and Brassica, and frequently show a tendency to change to white. In Rhaphanus (radish) the wild species, *R. raphanistrum*, is yellow, changing to white; while the garden radish, *R. sativus*, is white or pink. In Roripa (nasturtium) the two aquatic species are white, as well as the horse-radish, which grows wild along streams; the other species are yellow. In Draba four of the species are yellow and seven white, and *D. nemorosa* is yellow fading to whitish. In other species the calyx changes from green to yellow. It would seem probable that in these genera the white-flowered species have been derived from yellow progenitors; yellow appears to have been very early developed, and was not improbably the original color of this family.

The white flowers very frequently show a tendency to turn pink or purplish, and three genera contain both purple and white flowers. *Malcolmia maritima* has pink-red flowers, changing to violet purple. This transition is beautifully illustrated by the

rhizome of *Dentaria bulbifera*, which when taken from the earth is as white as ivory, but, if placed in a glass of water and exposed to the light of the sun, in a few days turns to a deep violet. The cultivated varieties of the genus Mathiola (stock, or gilly-flower), from Europe, present a wide range of colors, — as white, yellow, red, violet, and blue. The colors of Iberis (candytuft) are white, red, and purple; and the marginal flowers of this genus and of Alyssum and Dentaria have the outer petals enlarged, as occurs in the Umbelliferæ. *Hesperis tristis* has dark-colored flowers, visited at night by insects, which are attracted by the scent.

The inflorescence is in umbel-like racemes, which in fruit become greatly elongated. The central green buds and the surrounding flowers form a nearly flat surface and present a variety of color contrasts. Kerner has described several different classes. In *Draba verna* and *Thlaspi rotundatum* the green buds in the center are surrounded by two colored rings, — an inner one of small white flowers and an outer one of brown or purplish fruits, to which the petals, now enlarged to twice their original size, closely adhere. A variegated effect is thus produced. In *Thlaspi alliaceum* and *T. arvense* the flowers of the inner ring are white, but in the outer ring the green sepals have changed to yellow, while the fruit remains green. In a third group the inner ring is composed of flowers with colored petals, which in the outer ring have faded to white. In *Draba aizoides* there is a change from yellow to white, and in *Arabis cærulea* from blue to white. A fourth group is represented by *Æthionema grandiflorum*, in which the upper and under sides of the petals are differently colored. The flowers of the inner ring present the white upper side of the petals, but in the outer ring the petals have changed their position so that the red underside is now visible.

While the flowers of the Cruciferæ show that conspicuousness is correlated with the visits of insects, they furnish little evidence that particular colors have been evolved by the selective tastes of special insect groups. Both yellow and white flowers are visited by Syrphidæ, and they are also very frequent visitors to the inconspicuous but scented flowers of *Lepidium sativum*.

The blue flowers of *Arabis cœrulea* are likewise sought by flies, while the nocturnal flowers of *Hesperis tristis* are dark-colored and dependent upon their fragrance. The parti-colored appearance of the flower clusters and the changes of color of individual flowers would indicate that the guests were a miscellaneous group of insects, with the color sense but feebly developed. How comparatively unimportant the color of a flower may become is well illustrated by *Lepidium sativum*. The small white flowers can be seen only a short distance, and in rainy weather do not expand. Yet they possess a strong scent, and Müller found them visited more frequently by insects than any other crucifer. Throughout the species of this family the petals have not been extensively modified either in form or color.

The flowers of the Capparidaceæ resemble those of the Cruciferæ both in form and color. *Polanisia graveolens* (clammy weed) has purplish sepals and stamens, and whitish petals.

There are three species of mignonette (Resedaceæ) in the northern states. The flowers are especially attractive to small bees of the genus Prosopis. These bees, which have an aromatic odor, are coal black, marked with yellow. They are doubtless attracted by the sweet fragrance, which can be perceived at a long distance. *Reseda luteola* (yellow weed) has greenish-yellow flowers and is cultivated for its yellow dye. *R. alba* has white flowers. In *R. odorata* the receptacle is at first yellow, changing to orange red; the petals are white or red, and the anthers red. The perfume is intense. On flowers growing in his window Müller collected five species of Prosopis, besides other insects. The strong scent of these flowers probably compensates for their small size and greenish colors.

The Sarraceniales contain two remarkable carnivorous families, the Sarraceniaceæ, or pitcher-plants, and the Droseraceæ, or sundews. The leaves, which are adapted to trap insects, are more conspicuous than the flowers. *Sarracenia purpurea* has purple-veined leaves and large purple flowers, while *S. flava* has green leaves and yellow flowers. The walls of the orifice, and the hoods, or lids, of the pitchers are the most highly colored parts. Leaves without ascidia or pitchers are green. The upper part of the pitcher of *S. laciniata* is pure white, marked

with a network of dark red veins. Of the five northern species of Drosera, four have white and one purple flowers. The red glandular leaves are far more prominent than the flowers. In the common *D. rotundifolia* the small white flowers open at midday, one or two at a time, and are visited sparingly by flies.

The order Rosales includes some thirteen families, differing but little from each other. The Saxifragaceæ, according to Engler, form the center of development, while the Rosaceæ and Papilionaceæ are regarded as sister families. The primitive character of many of the genera appears in the indefinite number of the stamens and pistils and their separate insertion upon the receptacle. The order, however, exhibits an advance upon the Ranales in that the carpels are more often united and the ovary inferior.

Of the Crassulaceæ, or orpine family, two species are green, two white, five yellow, two red, and two purple. The two green-flowered species have small flowers and grow in wet places, and in the case of *Penthorum sedoides* (ditch stonecrop) the petals usually are wanting. The genus Sedum (stonecrop) contains white, yellow, red, and purple flowers, with the honey readily accessible to short-lipped insects. In *S. acre* the leaves are yellowish green and the flowers yellow. While the blossoms are small they are produced in such profusion that they completely cover the plants, which grow in dense tufts and are sometimes called "golden moss." In *S. telephium* the petals are purple and often the entire plant. The honey is more deeply concealed than in the preceding species, and the flowers are in broad cymes, which are conspicuous and facilitate insect visits. In the species of Sempervivum the honey is still more deeply hidden and can be reached only by long-tongued insects. The cymose flowers are showy pink or purple. The petals of *Sempervivum wulfenii* are sulphur yellow with a purple base, and are pollinated by bumblebees. This purple coloring Müller believed to be a remnant inherited from a purple-flowered ancestor, from which the sulphur-yellow form, which is unlike the primitive yellow form of Sedum, had been developed by the selective influence of bumblebees. This color change is not improbable, for the petals of *Arnebia cornuta*, when they expand, are marked with dark

purple spots, which on the third day fade entirely away, leaving the flowers bright yellow. The colors of the flowers of the Crassulaceæ are often correlated with the colors of the stems and leaves.

The flowers of the Saxifragaceæ are small and arranged in racemes, cymes, and panicles, or solitary in Parnassia. The honey in most species is easily accessible, and the visitors are chiefly flies, which appear to have influenced the development of the coloring. To these insects white and yellow, marked or dotted with yellow, red, or purple, are thought to be especially attractive. The relation of Diptera to the flowers of Saxifraga is shown in the accompanying table compiled from Müller and Knuth.

Species.	Color.	Diptera.	Hymenoptera.	Coleoptera.	Lepidoptera.	Total.
S. rotundifolia .	White	14	1	—	—	15
S. stellaris . . .	White	12	2	1	1	16
S. aspera	White	2	—	—	—	2
S. bryoides . . .	White	9	2	2	—	13
S. aizoön	White	65	11	5	10	91
S. cæsia	White	15	3	3	3	24
S. exarata	White	4	1	—	—	5
S. muscoides . .	Greenish yellow	6	1	1	1	9
S. aizoides	Golden yellow .	85	20	8	13	126
S. oppositifolia .	Purple	4	—	1	3	8
Total		216	41	21	31	309

The genus Saxifraga is highly interesting because of the colored dots upon the corolla of many of the species. The white corolla of *S. rotundifolia* is sprinkled with round dots, the outer

of which are intense purple red; the inner are yellow, and the anthers white. The snow-white petals of *S. stellaris* are beset with purple dots and adorned with two orange-yellow spots. *S. aspera* and *S. bryoides* are white, with numerous shining yellow dots. *S. aizoides* has large golden-yellow flowers, marked with numerous orange-red dots; the nectaries and anthers are also yellow. This is the most conspicuous species of the genus and attracts 126 insects. *S. oppositifolia* has the honey more deeply concealed and is carmine or purple, and is diligently visited by butterflies. *S. hirculus*, of Labrador, is bright yellow with scarlet spots. In *S. michauxii* the three largest white petals have a pair of yellow spots at the base, but the two smaller are unspotted. The petals of *S. geum* are white, with a yellow spot at the base and several smaller purplish spots in the middle. As evidence that these markings are pleasing to Diptera, Müller states that he saw many specimens of two drone flies, *Sphegina clunipes* and *Pelecocera scævoides*, before sucking honey or eating pollen, poising before the dotted flowers of *S. rotundifolia* as if delighted by their appearance.

In his *Alpenblumen* Müller has tabulated his observations upon the relations of Diptera to the different colors of flowers. Most anthophilous species and families of flies made a much larger number of visits to white and yellow than to red and blue flowers. The Bombylidæ, which are suctorial only, showed a preference for red and blue to white and yellow in the proportion of 75 to 25; and the genera Volucella and Rhingia, of the Syrphidæ, showed a similar inclination in the proportion of $77\frac{2}{10}$ to $22\frac{8}{10}$. The less specialized Diptera were by far the most common on white and yellow; but as the proboscis increased in length and the species confined themselves more strictly to flowers, the percentage of visits to red and blue flowers increased from $14\frac{1}{10}$ in the Muscidæ to $29\frac{3}{10}$ in the Syrphidæ, and to 75 in the Bombylidæ. The Syrphidæ as flower visitors surpass all other Diptera, both in numbers and importance. The percentage of visits to yellow and white was $69\frac{7}{10}$, and to red and blue flowers was $29\frac{3}{10}$. The species marked yellow, whether short or long tongued, were two to three times as abundant on white and yellow as upon red and blue flowers. None of the Tabanidæ,

which do not restrict themselves to flowers, were observed on red and blue blossoms. Due consideration should be given to the limitation of the visits of flies by the form of the corolla, by scent, by the acuteness of the species in finding the honey, as well as by its adaptations and habits, and to the fact that in the case of several families the above conclusions are based on comparatively few observations.

Chrysoplenium alternifolium has no petals, but the sepals are bright yellow and the disk is also yellowish. Like the species of Saxifraga, it is visited chiefly by flies. The petals of Parnassia are white, with greenish veins. *P. palustris* is described as a "deceptive flower." It contains numerous yellow glandular bodies which appear like minute drops of honey, by which flies, especially Syrphidæ, are deceived. The flower contains a small amount of honey. In Hydrangea the cyme is made conspicuous by the enlargement of the calyx of the marginal flowers. In *H. hortensia*, cultivated from eastern Asia, the flowers are nearly all neutral and enlarged, and at first are green, changing directly to pink or purple. "The variable character of Hydrangea flowers," says a writer in the *Journal of Horticulture*, "when the plant is grown under certain conditions, has for many years been a sort of horticultural puzzle, which is still far from being satisfactorily solved. Plants with bright pink flowers, and those with flowers of a tolerably good blue, are not infrequently met with in positions near each other and apparently in soils exactly alike." A change of color in the flowers from pink to blue is sometimes caused by a change of soil, as the removal of a plant from a peaty soil to one of opposite character. The addition of iron to the soil frequently appears to produce the desired color change, though time is always required, the blue coloring not developing until the second year. *Saxifraga pennsylvanica* and *Heuchera americana* have green petals. Several species of Saxifraga are proterogynous, and the flowers in passing from the female to the male stage increase greatly in size.

The Grossulariaceæ (gooseberry family) contain only a single genus, Ribes. Of the northern species four are green, six white, one yellow, and two greenish purple. Most of the species are greenish in part. In *Ribes alpinum* the female flowers are green

and the male greenish yellow and much more conspicuous, though of no larger size. By this device insects are induced to visit the male, or pollen-bearing flowers, first. The petals of *R. sanguineum* change from white to pink, and of *R. aureum* from yellow to carmine. This color change, says Müller, also occurs in several species of Fuchsia and Lantana and enables the more intelligent bees to economize time by determining instantly those flowers which no longer contain nectar.

There are four green, thirty-five white, thirty-nine yellow, thirteen red, and four purple flowers in the Rosaceæ. The green flowers are small and apetalous, as in Alchemilla; the white flowers are very generally tinged or tipped with red, and vary from small in Spiræa to large in Rubus. Of the twenty genera in the northern states, twelve contain white flowers. Of the four species in Spiræa, three are white and one, *S. tomentosa* (hardhack), is rose, or rarely white. The flowers contain nectar and attract numerous flies, beetles, and Hymenoptera. Beetles are very frequent visitors to the small white flowers of *Aruncus aruncus*. The genus Rubus contains seventeen species, all of which are white except the purple *R. odoratus* and the pink *R. arcticus*. *R. strigosus*, or the wild red raspberry, has small, erect white petals, and the visitors are much fewer than to the blackberry, *R. villosus*. Though the flowers of the blackberry are also white, their increased conspicuousness secures them a much larger company of visitors, which is not far from one hundred. The petals are broad and flat, and the panicles large and numerous. *Dalibarda repens*, a woodland plant, produces both cleistogamic and open white flowers which are seldom fertile. The common field strawberry blooms in May and June, when the white blossoms contrast with the green meadow, and the growing grasses are as yet too short to conceal them.

Of the twenty-four species of Potentilla, two, *P. arguta* and *P. tridentata*, are white and are probably derived from yellow-flowered ancestors. They both grow in dry, rocky places. The other twenty-two species are yellow and are visited by small bees and flies. The prevalence of yellow coloring in this primitive genus would indicate its early development in the rose family. Yellow is also the color of *Duchesnea indica* (Indian

strawberry), which is certainly closely allied to the line of the field strawberry. *Waldsteinia fragarioides*, or the barren strawberry, which in leaf habit has the aspect of Fragaria, is likewise yellow. The simpler species of avens are yellow or white, while those with the honey concealed are purple. In *Geum rivale* (purple avens) the petals are purplish orange and the calyx brown purple. The honey can be reached only by long-tongued bees and flies, such as Bombus and Rhyngia. In *Comarum palustre* (marsh cinquefoil) the petals are purple and the sepals also inside. The plant grows in swamps and is visited by flies and less frequently by bees. The primitive color of both these species seems to have been yellow. The purple-flowering raspberry, *Rubus odoratus*, is however derived from white-flowered progenitors, for in New York at Pine Hill, Ulster County, a white-flowered form occurs, and the white species of this genus are frequently reddish or purple.

The ten species of Rosa in the northern states are rose or pink, varying to white. Though the flowers contain no honey, their color and fragrance attract many insects to the ample store of pollen. Several species have odors so peculiar that they may be recognized by them alone. The theory of Delpino that the distribution of this genus was determined by the range of certain families of Coleoptera has been disproved by the observations of Müller and others who have found bees very frequently upon the flowers. Beetles may often be collected, some species of which devour the petals bodily. The flowers of *Rosa canina* gain increased conspicuousness by always turning towards the sun. In Germany they are visited by eight beetles, six bees, and two flies.

The family of the Rosaceæ is very prolific in hybrids, and more than two hundred have been observed in nature. Innumerable hybrids of Rosa have been produced under cultivation which display countless combinations of yellow, red, and white, — as white tinged with yellow or pink, yellow fading to white or shaded with rose, or pink changing to white, rose shaded with yellow, or intense coloring such as crimson, carmine, and scarlet. In one variety on the same root there are produced every intermediate shade between white and red, and in another the colors

vary from yellow to crimson. There is no blue rose, but a white variety of *Rosa rugosa* from Japan has a bluish tinge. Blue does not, indeed, occur in this family. While red is common, none of the Rosaceæ are adapted to Lepidoptera. The visitors are a miscellaneous company of flies, beetles, and Hymenoptera.

This family exhibits a marked tendency in stem, leaf, bud, flower, and fruit to develop reddish coloration, — a tendency which is probably due to the chemical constitution of the sap. The smaller and less specialized Rosaceæ are yellow and white, and are visited by a variety of short-lipped insects. The increase of the white flowers in size and conspicuousness is usually attended by red coloration. Owing to the chemical constitution of the nutritive fluid, probably to its acidity (for when the petals of a rose are treated with ammonia they become blue), there has been no opportunity for the development of blue coloration by insects. With the enlargement of the perianth and the increased flow of sap, red tints have tended to appear by process of oxidation. The correlation of red coloring with an increased flow of the sap is well illustrated by the galls of the wild rose tree, which are often "as rosy as the rosiest apple." An abnormal flow of sap is caused to the part stung by the insect, and red coloration is due to the action of light, for it is of no service to the plant. Again, when the flowers of *Cratægus coccinea* are stung by the gallfly the different organs all become red, and the change in coloring is accompanied by an increase in size. In some instances, according to Darwin, red colors indicate greater vigor on the part of the plant, and I have also observed that the dwarfing of red flowers under cultivation may cause them to revert to white.

There is nothing more beautiful in the vegetation of the temperate zone than an orchard laden with expanding blossoms. The great quantities of flowers form billowing banks of whiteness, tinged with rose and flecked with the vivid green of the unfolding leaf buds, from which exhales the well-known sweet fragrance of the apple blossom. Of the Pomaceæ, or apple family, twenty-seven species are white and five red or partially white. The flowers are regular and usually clustered. Species

of Sorbus (mountain ash) and Cratægus (thorn) are very attractive to beetles, though often visited by flies and bees. The pear and apple are sought by fewer beetles and depend chiefly upon Hymenoptera and Diptera. The native species of apple are rose or pink, but readily change to white. The so-called bloomless apple has small green petals resembling sepals.

Twenty species of the Drupaceæ, or plum family, are white, and one, the peach, is pink. The blossoms of many plums appear in early spring in advance of the leaves and often completely wreathe the limbs. The flowers are visited by a great number of Andrenidæ, and in less than two hours I collected one hundred and twenty specimens on a Japan plum, and these were but a small part of those present.

The Mimosaceæ, Cæsalpiniaceæ, Krameriaceæ, and Papilionaceæ are often united in one family called the Leguminosæ, because the simple pistil becomes in fruit a legume. The Mimosa family connects the rose family with the Papilionaceæ. It is confined chiefly to the tropics, where the species are very numerous. The flowers are small, perfect, and regular, with the stamens distinct as in the rose family, or monodelphous as in the Papilionaceæ. In the northern species the colors are white, yellow, or pink. The filaments are long and threadlike, and are more conspicuous than the petals.

The pea, bean, clovers, vetch, and a whole host of leguminous allies are grouped together in the Papilionaceæ, — a name derived from the fancied resemblance of the flowers to a butterfly. Occasionally perfectly regular flowers occur by reversion, as has been observed in Laburnum. For the most part, nine of the ten stamens unite to form a tube, at the bottom of which lies the honey, if present ; four of the petals interlock around this tube, while the fifth, called the "standard," is broad and erect and bright colored to attract the attention of insects. The flowers are fertilized by bees, which rest upon the wing petals, bracing the head against the standard and bringing the ventral side of the body in contact with the stigma and pollen. The irregularity of the flowers is due to their horizontal position and the unequal strains to which the petals are subjected. In the case of certain species bees alone are able to depress the keel

and obtain the nectar, and in their absence the flowers fail to set seed. Slight imperfections frequently permit flies and butterflies to steal the honey without rendering any service in return; and it has been suggested that the numerous species may be due to the efforts of the plants, metaphorically speaking, to remedy these defects.

The inflorescence is mainly in heads and racemes, but the effect of the individual flower cluster is often magnified manifold by the massing of the plants. In worn-out fields the vetch, *Vicia cracca*, often takes entire possession of the soil, forming large patches of purple blue. Similar effects are attained by the clover and wild lupine. Of the 197 species in the northern states, 39 are white, 33 are yellow, 13 red, 88 purple, and 24 blue. The predominance of blue and blue purple are believed to be due to the preference of bees for this color. The well-known experiments of Lubbock have shown that the honeybee can distinguish between colors. Scarlet, fire red, and all lurid colors are avoided by the honeybee. Blue, violet, and red are most attractive, followed by various shades of purple, yellowish white, and white.

An examination of the genera in which more than two species occur shows that they are rarely monochromatic; one or more species are usually differently colored from the rest. In Baptisia three species are white, two yellow, and one blue; in Trifolium (clover), four species are white, three yellow, four red, and three purple; in Psoralea two species are white, six purple, and three blue; in Astragalus seven species are white, three yellow, twelve purple, and one blue; and in Meibonia (tick trefoil), two species are white, one red, and nineteen purple. It is probably more advantageous in these genera for a part of the species to be of one color and a part of another than for all to be blue. When species are closely allied bees tend to visit them indiscriminately, as may be observed in the buttercups and goldenrods. But even in these cases they exhibit a preference to keep to a single species and would be greatly aided by differences in the coloring.

Many of the flowers of the Papilionaceæ in fading undergo a change of position and color. In the white clover the white

central flowers contrast with an older outer ring of rose-colored flowers. In the yellow clover the newer flowers contrast with a ring of chestnut brown. In *Vicia cracca* the older flowers bend downward and turn from violet blue to dark purple; while the purple flowers of Desmodium become green in withering. Striking color contrasts are also presented by the individual flower. The wings of the white corolla of *Vicia faba* (bean) are marked with two black eye-spots, and in the sweet pea and cultivated lupines the combinations of color are innumerable. *Astragalus vesicarius* has yellow blossoms in the Tyrol but violet on the limestone mountains of Hungary.

Nine families belong to the order Geraniales. In the genus Geranium of the Geraniaceæ the larger and more conspicuous purple flowers are visited abundantly by insects and have nearly or quite lost the power of self-fertilization. The smaller flowers are paler or white, attract few insects, and self-fertilization regularly takes place. *Geranium pratense* has been seen to produce on the same plant, when cultivated in a garden, both white and blue flowers. *G. robertianum*,[1] or red robin, has ribbed red-purple petals and, notwithstanding its disagreeable odor, is sought by bees as well as flies and beetles. In the pink flowers of *Erodium cicutarium* the upper petals are marked with dark lines, which serve as pathfinders. According to a series of forms figured by Knuth these markings vary greatly, from a few lines to spots and markings on all five petals.[2] In the genus Pelargonium from the Cape of Good Hope, this office of the upper petals becomes very highly developed; *P. tricolor* has the three lower petals white and the two upper crimson, each with a dark spot at base. The flowers of the Geranium always turn towards the sun.

Most of the northern species of Oxalis of the Oxalidaceæ are yellow and possess an acid juice, but *O. acetosella*, which grows in open woodlands, has large, pretty white flowers, veined with pink. It is sometimes called "wood sour," as druggists obtain from it salt of lemons. The plant is of social habit, and the flowers are quite conspicuous, yet are rarely visited by flies,

[1] Darwin. *Animals and Plants under Domestication*, vol. i, p. 404.

[2] Knuth. *Handbuch der Blutenbiologie*, Bd. i, p. 118.

beetles, or bees. Cultivated species of Oxalis are red or rose. *O. flava* is yellow, edged with red; and *O. versicolor* is white above and red beneath, so that the blossoms are white in the sunshine, and red when rolled up in the shade.

Like the Papilionaceæ, the flowers of the Polygalaceæ stand horizontal, and the petals are more or less united into a tube with a carina and alæ. The largest-flowered species is the fringed Polygala, *P. paucifolia*, which in spring produces beautiful rose-purple crested blossoms, with an occasional white variety. It is attractive to butterflies as well as bees. On the Alps, Müller found one species of Polygala fertilized entirely by butterflies. Most of our species have very small flowers, which are either greenish purple, or yellow changing to green in drying.

In the capability of the leaves to develop bright colors, and in the minute and reduced flowers attractive to Diptera, the Euphorbiaceæ, or spurge family, resemble the Araceæ, though it has not the remarkable adaptations for fertilization of Arum. The spurge family is of immense size and of very wide geographical distribution. The flowers are minute and have undergone much reduction. They are usually apetalous, and the entire perianth may be wanting, as in Euphorbia, where a single stamen represents a flower, and the flower cluster with its colored involucre was mistaken by the older botanists for a single flower. The genus Euphorbia is attractive to flies, though also visited by beetles and Hymenoptera; and in response to their visits the inflorescence in certain species possesses bright colors, honey, and a honey-like scent. The colors of many northern species are green, but a part are white, yellow, rose, or red. On *E. cyparissas*, the common cypress spurge, naturalized from Europe, and which has escaped from cultivation, the bracts are yellow. In the Alps, Müller collected twenty-one flies, one beetle, four Hymenoptera, and three Lepidoptera on the flowers, and in middle Germany he found many more Coleoptera and Hymenoptera. The genera Ricinus and Croton are extensively cultivated for the tropical aspect of the magnificent foliage. *Ricinus communis* is anemophilous.

In the order Geraniales, to which the families just considered belong, and in the succeeding order, the Sapindales, the flowers

mark an advance upon the Rosales in that the cyclic arrangement prevails and there is an imperfect union of the carpels. The families of the Sapindales differ widely and have been divided into numerous subseries. The Empetraceæ, Buxaceæ, and Limnanthaceæ are represented in the northern states by only four species. The flowers are small, and probably partly primitive and partly reduced.

The Anacardiaceæ and a number of allied families are of much interest, as the inflorescence has been but little modified by insects. The species are mainly trees and shrubs with green, white, and greenish-yellow flowers, which are visited by Diptera and the smaller and less-specialized Hymenoptera. The Anacardiaceæ, or sumac family, have small, regular flowers in dense panicles. Both the sepals and petals are present, but the flowers are greenish or greenish yellow, though sometimes tinged with red as in the smoke tree. They secrete honey and are attractive to flies and Andrenidæ. On the smoke tree, *Cotinus cotinus* (*Rhus cotinus*), there have been collected six flies, one beetle, and ten Hymenoptera. The species tend to become diœcious, and *Cotinus cotinus* (*Rhus cotinus*) shows all transitional stages between staminate, hermaphrodite, and pistillate flowers. While the visits of insects have not developed bright colors, the leaves of *Rhus radicans* and the fruit of *R. aromatica* are red in autumn, and the wood of several species is orange yellow. *R. glabra* sometimes has the whole or a part of the flower cluster changed into small leaves.

The various species of Illicaceæ, or holly, have small white flowers, with freely exposed honey. The berries of *Ilex verticillata* are bright red, or rarely yellow, or even white. The visitors are similar to those of the preceding family. The Celastraceæ is composed of trees and shrubs with small, regular, green, yellow, and purple flowers.

Five species are green, three yellow, and one red in the Aceraceæ, or maple family. The green flowers of *Acer saccharinum* are without petals. In *A. rubrum* (red maple) the diœcious flowers are crimson, and the visitors are Andrenidæ and Diptera. There is no reason to suppose that the crimson coloring has been developed by insects, for the entire flower, the leaf

buds, the young leaves, and the twigs are of this color, while the bark yields a purple dye. The flowers appear in early spring before the leaves and were formerly anemophilous. *A. spicatum* blooms later, and the compound racemes of greenish-yellow flowers are large and erect. Müller states that dull-yellow flowers are avoided by beetles, but I have observed many beetles, as well as bees, upon the inflorescence of this species. Closely allied to the maple, but of more recent origin, is the genus Æsculus. The flowers seem to have possessed special capabilities that led to their adaptation to bumblebees. Among ornamental trees few present a more stately and splendid appearance when in blossom than the common horse-chestnut, *Æsculus hippocastanum.* It has large white flowers in crowded panicles, with the petals marked with yellow, which in a few days changes to orange and then to crimson. I have observed the honeybee, four species of Bombus, and one Andrena as visitors. Of the four other species of this genus three have yellow petals, and one, *Æsculus pavia,* bright-red flowers an inch in length.

Impatiens biflora, of the Balsaminaceæ, is orange yellow, spotted with reddish brown. One of the petals forms a spurred sac. August 10 I examined a large number of flowers; none of the spurs were perforated, and they were visited legitimately by *Bombus vagans,* which made from seven to twelve visits per minute. August 23 and 27 I found hundreds of the flowers perforated, and both honeybees and bumblebees stealing the nectar. If the Impatiens, fitly called "touch-me-not," could speak, what a protest it would utter! Various Diptera are attracted to the outside of the sac by the bright colors.

The colors of the Vitaceæ, or vine family, are green, closely resembling the foliage, and depend entirely upon their strong fragrance to attract insects. The inflorescence is in dense panicles. The calyx is minute, with the limb nearly obsolete. The green valvate petals form a hood over the stamens and never expand, but fall away by separating at the base and coiling spirally upward. The odor, which resembles that of mignonette, can be perceived at a long distance. "In a journey up the Danube," says Kerner, "through the part of the valley called the Wachan, with its vine-clad slopes, I found the air of the

whole valley, even that above the water, so filled with the scent of vine flowers that it seemed almost impossible they should be so far off. And yet the nearest vines on the banks were one hundred yards above the water and at least three hundred yards from the boat. Afterwards I found, when wandering through the vineyards, that the smell of the flowers close at hand was much weaker than at a distance, and was forced to the paradoxical opinion that with increasing distance and diffusion over a wider area the scent does not diminish but waxes stronger." Under cultivation the species are usually perfect, but when growing wild are mostly unisexual. Cross-fertilization, according to Knuth, is occasionally effected by the wind. As visitors to the flowers of *Vitis vinifera* there have been observed the honeybee, and various species of Halictus; while of Coleoptera, notwithstanding the green flowers, there have been enumerated twenty-one species. Müller's statement that "beetles are only or mainly attracted to flowers by bright colors" does not agree with the many species observed on the flowers of the vine.

Union of the carpels prevails in the order Malvales, which includes the two families Tiliaceæ and Malvaceæ. A part of the genera with the carpels distinct, or but slightly united, still preserves a more primitive stage in the evolution of the flower. As in the vine family, the flowers of the linden, or lime tree, depend on their strong scent, rather than upon their coloration, to attract pollinators. The greenish-white flowers of *Tilia americana* are in small, drooping, cymose clusters, sheltered beneath a floral bract. The thickened concave sepals secrete and contain the honey, which a pubescent fringe prevents from escaping. A high value is placed upon honey made from the linden; in some localities the leaves are also covered with a copious secretion of a sweet liquid, and sugar has been made from the sap. The strong scent, which is more noticeable at a short distance than close to the tree, is very attractive to the honeybee, many of which I have seen at work on the flowers in Maine. On *T. ulmifolia* in Germany Müller and Knuth collected eleven flies and seven bees. The absence of beetles I attribute not to the dull color of the petals, but to the inaccessibility of the drooping inflorescence, covered both by the leaves and the floral

bract. The leaves of a part of the species are bicolored, green above, and white, because densely woolly, beneath.

One-half, or thirteen, of the northern species of Malvaceæ are pink or red, four are red purple, five yellow, and four white. No other polypetalous family has so large a percentage of the flowers red. Both in temperate and tropical regions the blossoms are remarkably large and showy, and are usually yellow or red. The chief agents in intercrossing are bees. *Malva rotundifolia* has white flowers striped with pink, and slender pink stigmas, while *M. moschata* has either pink or white blossoms. The marsh mallow, *Althæa officinalis*, well known for the use of the mucilaginous root in confectionery, has pink flowers an inch broad; and *A. rosea*, the hollyhock of the garden, displays white, yellow, rose, crimson, purple, and black hues. A single species of Abutilon with yellow flowers has become naturalized from Asia. In South America the natural fertilizers of Abutilon are humming birds. The genus Hibiscus consists of splendid flowers of immense size. In color they are yellow, red, or white; the yellow forms have a purple or blackish eye, and the red a dark center. The common cotton, *Gossipium herbaceum*, one of the most valuable of nature's plant productions, has yellow petals, and the floral and extra-floral nectaries attract many insects as well as the ruby-throated humming bird.

Within the order Parietales the placentæ are parietal; "and the floral evolution," says Engler, "has already reached very complicated floral types." The Theaceæ (tea family) is mainly of tropical distribution, consisting of shrubs or trees with large solitary white flowers. Three species occur in the southern states. The handsome white flowers of *Stuartia malachodendron* have purple filaments; in *S. pentagyna* the petals are cream color and the sepals reddish outside. To this family belong the tea plant and the Camellia.

The Hypericaceæ have nearly monochromatic flowers, as twenty-two species are yellow and two red. The larger flowers of Hypericum are bright or orange yellow, as *H. ascyrum*, while the smaller are often pale yellow. The leaves, sepals, and petals of *H. maculatum* are sprinkled with numerous black dots. *H. perforatum*, introduced from Europe, contains no honey, but

the large, black-dotted, bright-yellow flowers attract many flies, which feed on the pollen. The smaller-flowered species are rarely sought by insects, and self-fertilization is possible throughout the genus. The two small, reddish-flowered species belong to the genus Triadenum. The petals of *Triadenum virginicum* are rose colored, with deeper veins, and do not exceed the calyx; the honey glands are orange and the anthers bright yellow with white filaments. The flowers are very sparingly visited by insects, and after repeatedly watching them I have observed only two bees and three flies. The stem, the capsule, and often the leaves are a deep crimson, as is often the case in Hypericum. The change in the petals from yellow to red is probably correlated with the red coloration of the plant rather than due to insect selection. In *Hypericum perforatum*, which frequently has the foliage crimson colored, the yellow petals are tinged with rose in the bud, which fades away as the flower opens. In *Epilobium palustre* reddish flowers are more common when the stems are red than when they are green.

In the Cistaceæ, or rock-rose family, the genus Helianthemum (frostweed) has large yellow flowers, which throughout the day follow the sun. They are ephemeral, but the plants remain in blossom for a long time, as there is a succession of flowers, as in the crucifers. There is no honey, but the pollen attracts a miscellaneous company of insects. As is frequently the case in pollen flowers, pollen falling from the anthers is not lost but lodges in the concave petals. The small greenish flowers of Lechea (pinweed) are self-fertilized.

The violet family in the northern states contains 7 white, 6 yellow, 4 purple, and 17 blue flowers. About 300 species of this family and 150 of the genus Viola have been described. Müller regards yellow as the original color of the violets. The small, short-spurred *V. biflora*, which in the Alps is fertilized by flies, has yellow flowers; the large-flowered *V. tricolor*, variety *alpestris*, presents all stages in the passage from yellow to blue. "Many plants have flowers which are yellow throughout; in others the flowers are yellow when they open but change gradually to blue; and in others the change to blue occurs immediately after opening, or even before." *V. calcarata*, which has a spur

from 13 to 25 mm. in length and is fertilized by Lepidoptera, chiefly by *Macroglossa stellatarum*, displays, according to Kerner, in the meadows of the western Alps a blue corolla, and a yellow corolla in the eastern Alps. Darwin transplanted a large, uniformly colored, dark-purple variety of the pansy while in full flower, and it subsequently produced smaller flowers, with the lower petals yellow. The white forms appear to be derived from blue progenitors, for the former are purple veined and may be tinged with violet. Blue species of Viola which often have white flowers are *V. palmata*, *V. obliqua*, and *V. odorata*, and in various stages *V. canadensis*. Pathfinders among white northern polypetalous flowers are of infrequent occurrence. The most prominent instances are *Saxifraga michauxii*, with three of the unequal white petals marked with yellow; *Oxalis acetosella*, white with reddish veins; Parnassia, with greenish veins; *Magnolia macrophylla*, *Æsculus hippocastanum*, *Lespedeza hirta*, and *L. capitata* display purple spots. In the white violets the purple honey guides are highly developed, which may be best explained by supposing them descended from blue-flowered ancestors with darker veins similar to existing species.

The beautiful and richly variegated varieties of *V. tricolor*, the garden pansy, are due partly to selection and partly to hybridization. The corolla may be pure white, yellow, red, blue, purple, or black; or there may be combinations of yellow and blue; yellow and red; yellow, blue, and white; and blue and white. According to Strasburger, in the pansy the cells of the epidermis of the petals contain both violet sap and yellow granules. "The striking diversities in color presented by different parts of a given petal depend wholly upon combinations of these two elements of color, — namely, violet sap and yellow granules."[1] Places which are devoid of both these elements are white, as the light is refracted and reflected by the intercellular spaces containing air. When sections of white roots of a violet plant are exposed to the air they change to violet; and the leaves of *V. cucullata* when grown at alpine altitudes become yellow.

While the violets vie with the roses in popular favor, they do not prove attractive in an equal degree to insects. In Maine I

[1] Goodale. *Physiological Botany*, p. 170.

have rarely observed visitors to the white and blue varieties, but on the yellow *V. rotundifolia*, which blooms early in May, I have seen many bees belonging to the genera Bombus, Nomada, and Andrena. Besides the conspicuous flowers, which are often unfruitful, many species produce cleistogamic flowers, in which the petals are reduced to mere scales, but the green sepals remain essentially unchanged. Occasionally the violets bloom a second time in late fall.

The failure of the yellow plastids to develop and the predominance of the colored cell sap produce blue flowers, and the non-development of both color elements results in white blossoms. In these color changes other ecological factors are more important than insects. For instance, of the yellow-flowered species one is visited by flies, another by bees, and the either yellow or blue *V. calcarata* is adapted to Lepidoptera.

The passion flowers are mostly natives of South America and are fertilized by humming birds and bumblebees. The calyx of the common *Passiflora cærulea* remains green until it has attained nearly its full size, when it changes to blue and white; the petals are white; the outer corona consists of several rows of blue filaments banded with white, but the inner corona is smaller and unmarked. Fritz Müller considered the coronæ to be of service in detaining small insects and keeping them caged for humming birds.

The Cacti, of which over a thousand species are natives of America, are especially abundant on the sandy plains of Mexico. The nearest living representative of the ancestral stock of this family is the genus Pereskia, which still possesses leaves of the usual form. "The earliest derived line was Opuntia. From the primitive Opuntia forms the columnar Cereus line was derived, with its numerous generic branches and diverse habits. Low down upon the columnar Cereus line the Echinocactus line branched out, which gave rise later to Mamillaria and still later to Anhalonia" (*Botanical Gazette*, Vol. XXVII, No. 3, p. 228). The flowers of the Cacti are solitary and sessile, with the sepals and petals and stamens numerous and spirally arranged. In size they are usually large and showy, as in *Cereus grandiflora*, queen of the night, where they are 20 cm. in diameter. In Pereskia

the flowers are white or yellowish; in Opuntia yellow, or in *O. opuntia* and *O. humifusa* yellow with a reddish center; in Cereus in the nocturnal forms white, in the diurnal species red or crimson; in Echinocactus yellow, white, and crimson; in Mamillaria yellow, pink, white, and purple; and in Anhalonia white, rose, and purple. The spines of the Cacti are often very beautiful objects and exhibit a great variety of color, as white, black, yellow, red, and purple. The stems, while usually green, are frequently nearly blue; the fruits are green, red, and purple.

The Thymeleaceæ and Eleagnaceæ in the northern states have no petals, but the calyx is enlarged, prolonged into a tube, and colored yellow, red purple, or white. In Europe *Daphne mezereum* has the red-purple flowers visited by long-tongued bees, flies, and butterflies; in the Alps the white or red flowers of *D. striata* are strong scented in the evening and are visited by moths.

The petals are wanting in the single green species of the Lythraceæ, or loosestrife family, *Didiplis diandra*, which has minute solitary flowers. The loss of the corolla is doubtless due to retrogression. In Ammannia the flowers are small and the purple petals fall away as soon as they expand, and in the southern *A. latifolia* they are wanting. The purple flowers of Lythrum vary from small to large. The eighteen possible ways of fertilization in the red-purple trimorphous flowers of *Lythrum salicaria* were made the subject of a long series of laborious experiments by Darwin, which resulted in breaking down the last barrier between species and varieties. It is a singular fact that the pollen of the longest stamens in this species is green, and of the middle-sized and shortest, yellow. The legitimate fertilizers are long-tongued insects. In Parsonia, or Cuphea as it is better known, the flowers are pink or crimson, and in a cultivated species from Mexico, *C. platycentra*, there are no petals, but the tubular calyx is bright vermilion with a violet border.

The Melastomaceæ are represented in North America only by the genus Rhexia, with handsome purple or yellow flowers. The family is most abundant in South America. In Heeria a part of the stamens are devoted to rendering the flowers conspicuous and a part to producing pollen. *Cyanophyllum*

metallicum, from Central America, has magnificent leaves, purple beneath and metallic blue above.

In the Onagraceæ, or evening primrose family, there are three green, fourteen white, twenty-four yellow, ten red, and six purple flowers. The three small green flowers belong to Ludwigia, and the petals are either minute or absent. Many of the white flowers show a tendency to change to pink or red. The large white flowers of the three northern species of Anogra all turn pink with age. Several species of Gaura also change to red. *G. coccinea* is red, turning scarlet in fading. The two species of Circæa (enchanter's nightshade) are delicate, colorless little plants, which grow in damp, shady woods and have small white flowers, fertilized by flies. The yellow flowers are in part diurnal and in part nocturnal as in *Onagra biennis*. Yellow is a much rarer color than white in flowers expanding at night.

With a single exception the flowers of Epilobium are red or red purple. *E. angustifolium*, called "fireweed" (as the plants spring up in abundance in newly cleared or burnt lands), has very conspicuous flowers in long, terminal racemes. The sepals and petals are purple red, except the lower sepal, which is white, and rarely the whole flower reverts to white. The pollen is greenish purple, and the stems and seed vessels are purple. Honey is secreted by a green, fleshy ring at the base of the style. Bumblebees are the most important agents in intercrossing and will visit as many as thirty-seven flowers in a minute. I have collected on this species twenty-one Hymenoptera, five Diptera, three Lepidoptera, and two beetles. In the smaller species of Epilobium, such as *E. palustre* and *E. lineare*, the small flowers are reddish or white, both kinds occurring on the same plant. When the stems are purple the flowers are more often red than when the stems are green. There are few visitors, and self-fertilization regularly occurs. The only northern white species of Epilobium is *E. alpinum*, which has small white flowers which are regularly self-fertilized. In *E. hirsutum* the four white stigma lobes form a cross on the red field of the petals.

The exotic genera deserve special mention. In *Lopezia racemosa*, from Mexico, there are on two of the petals dry,

shining, yellow bodies, which appear like drops of honey and are deceptive to flies, like the mock nectaries of Parnassia. The species of Fuchsia are confined chiefly to the shady forests of Central and South America. Both whorls of the perianth are highly colored, the calyx and stamens crimson or scarlet, and the petals purple or red. The flowers are pendulous and visited by humming birds. Crimson or scarlet flowers are not common where there are no humming birds. Kerner calls attention to the rarity of scarlet in south Europe compared with its frequent occurrence in tropical America, where in the primeval forests there are a great number of scarlet or fire-red species of Begonias, Fuchsias, Lobelias, Erythrinas, Salvias, and other crimson blossoms, which are surrounded by humming birds. Many hybrids of Fuchsia have arisen under cultivation. The earliest white-sepaled form was produced in England in 1822, while the first white corolla was secured in 1853.

In the Haloragidaceæ, or water-milfoil family, the petals are small or wanting and the flowers are wind-fertilized. The species are mainly aquatic.

The last of the polypetalous orders is the Umbellales, which includes the Araliaceæ, Umbelliferæ, and Cornaceæ. The flowers are small and densely aggregated in umbels, cymes, and panicles. In the ginseng family, or Araliaceæ, the flowers are white or greenish. In open, sunny thickets many plants of *Aralia hispida* grow together and produce numerous umbels of inconspicuous flowers with small white petals. The honey is abundant and freely exposed, and I have collected upon the flowers eighty-two visitors. Bees, with the exception of the honeybee, are not common; but the less specialized Hymenoptera, such as ichneumon flies and wasps, are numerous. Notwithstanding their want of bright colors, the flowers are very attractive to the butterfly *Argynnis aphrodite*, several of which may often be seen at work on the same plant. Though *A. racemosa* may be found growing but a short distance from *A. hispida*, its habitat is within the precincts of shady woods, where the greenish flowers attract a much smaller circle of guests. The green flowers of *A. nudicaulis* (wild sarsaparilla) are also visited by few insects. The color of *A. hispida* appears to be of slight

importance in attracting insects, compared with its sunny, sheltered location and easily accessible supply of honey.

Few plant families have attained a form of inflorescence so well adapted to insure cross-fertilization as the Umbelliferæ. To this family belong the caraway and carrot, the wild parsnip, the water hemlock, and parsley, — plants growing luxuriantly by the roadside, along the river, and in the meadow. There are about 1600 species, mostly confined to the temperate zone. The flowers differ very little in structure, and the species can be identified only by the mature fruit. The small flowers gain conspicuousness by aggregation, and by standing in the same horizontal plane afford a convenient landing place for insects, and admit of rapid fertilization. The honey is secreted in a thin layer by the fleshy disk surrounding the style. The number and variety of the visitors surpass those of all other families. In Germany there have been collected on the caraway 55, on the wild carrot 61, and on the wild parsnip 118 insects. Probably the number of visitors to many species exceeds 200; while there is thus ample provision for intercrossing, self-fertilization is in most species prevented by the anthers and stigmas maturing at different times. Admirable simplicity and perfection are here combined.

There are 58 white, 16 yellow, 1 purple, and 3 blue flowers. As in the Cruciferæ, which have also very uniform flowers, white and yellow predominate, red and purple are more rare. The 16 yellow flowers belong to 11 genera, only three of which contain more than one species. In his *Fertilization of Flowers* Müller enumerates 7 Diptera and 7 Hymenoptera collected on the dull-yellow flowers of *Pastinaca sativa;* 4 Diptera and 4 Hymenoptera on *Bupleurum falcatum;* 15 Diptera and 31 Hymenoptera on *Anethum graveolens;* and remarks, "So the dull-yellow flowers of this plant, *P. sativa*, like those of Bupleurum and Anethum, are visited only by Diptera and Hymenoptera, not by beetles." On page 574 he adds: "All dull-yellow, dirty-yellow, brownish-yellow, yellowish-white flowers, *Bupleurum anethum*, Pastinaca, *Rhus cotinus*, *Galium mollugo*, Ruta, Neottia, Euonymus, Euphorbia, Adoxa, Alchemilla, are entirely or almost entirely avoided by beetles. The only apparent

explanation of these facts is that beetles are only or mainly attracted to flowers by bright colors. If this explanation is correct, dull yellow must be an advantageous color for plants with freely exposed honey, protecting them from injurious guests." Subsequent observations of Müller himself showed that *Bupleurum falcatum* was very frequently visited by the beetle *Mordella pumila*. In Schlesien, Loew observed on *Anethum graveolens* 5 species of beetles; numerous beetles were observed in the Tyrol by Schultz on *Rhus cotinus*, and on Euonymus both Schultz and Knuth observed beetles. The writer has found beetles very frequent visitors to the dull-yellow flowers of *Acer spicatum*. These illustrations need not be carried further, as it is evident that more extended observations have disproved Müller's generalization that dull yellow excludes the visits of beetles.

In the Umbellales both yellow and white have probably been derived directly from the primitive green. The involucre of *Cornus canadensis* changes from green to white, and the petals of many species of Cornus are green in the bud but become white as the flowers expand, while in the Umbelliferæ greenish-yellow flowers occur. In Apium one of the species is greenish yellow and two others are white. In Sanicula, *S. gregaria* has yellow petals exceeding the calyx and bright-yellow anthers, and *S. marylandica* has very small greenish-white petals and anthers. In Peucedanum three species are yellow and one white. White flowers may in some instances have been derived from yellow, as it has been shown that the yellow petals change to white in individual flowers in the Cruciferæ. As regards attractiveness to insects the yellow flowers of the Umbelliferæ do not appear to possess any advantage over their white competitors.

In Thespium two of the species have yellow flowers, and in the third they are purple, with a common yellow variety. Many of the white species tend to become pink or reddish. In *Daucus carota* the central flower of the umbel, and frequently of the umbellets, is purple, and I have often seen the entire umbel pinkish. The coloration of this single flower can, of course, be of no advantage to the plant in attracting insects, and Darwin supposes that it is a relic of a former ancient condition. I am

inclined to believe that it is due rather to the chemical constitution of the soil and nutritive fluids and the action of light. The terminal flower receiving the greatest amount of sap would be the first affected, then those of the umbellets, and finally the entire umbel. The color changes of many flowers appear to be due to such causes rather than to the influence of insects. In Low Germany *Pimpinella magna* is white, and in the more intense light of the Alps pinkish. Both rose-colored and yellow flowers have been found on plants of *Eriogonum ovalifolium* growing in silver-ore localities. Chemical analysis showed that the rose flowers contained arsenic, which was not present in the yellow. As a stimulus in nutrition may intensify the color, so a check in growth may cause it to revert to white.

Increased conspicuousness of the umbel is gained in some genera by the enlargement of the outer petals of the marginal flowers, as in Heracleum. White bracts subtend the white flowers of Astrantia, and yellowish bracts the dull-yellow flowers of Bupleurum, and in Eryngium the flower stalk is colored.

The Cornaceæ include many ornamental shrubs valued for their bright-red bark, their variegated leaves, the masses of handsome flowers, and the coral and blue berries. The flowers are chiefly white, but in the European *Cornus mascula* are yellow. The forty or more small white flowers of the herbaceous bunchberry *Cornus canadensis*, gain conspicuousness by an involucre of four white bracts, sometimes tinged with red. I have also seen the leaves partially white. This species yields very little nectar, which can be detected only by close examination. The blooming season lasts for over a month, and the flowers are produced in the greatest profusion. I have watched these plants long and carefully, and have enumerated thirty-six visitors; but not once have bumblebees been seen to visit the blossoms, — a fact I attribute to the scarcity of honey. The shrubby species contain a more abundant supply of nectar. The cymes are large and very numerous, and not infrequently are sought by bumblebees. On *C. alternifolia* I have collected twenty-eight insects. There can be no doubt that the quantity and flavor of nectar is an element in the limitation of insect visits, but one that has received much less attention than

coloration. *C. florida* is provided with an involucre that is usually white, but varies to pink or red. The fruit is scarlet and the leaves are bright red in autumn.

SUMMARY.

1. Throughout the Choripetalæ, with few exceptions, conspicuousness is correlated with fertilization by insects. In the grape family the flowers depend upon their strong scent rather than upon bright coloring. In many genera it is possible to arrange the species in a progressive series, in which there is an advance from inconspicuousness, few visitors, and self-fertilization, to many visitors, great conspicuousness, and the loss of the power of self-fertilization. Pigments may be developed in all the organs of the inflorescence, as bracts, stems, sepals, petals, stamens, and pistils.

2. The green flowers of the Polypetalæ are small, and the petals are frequently wanting. The white and yellow flowers vary from small to large, are the most common, and contrast more strongly with the foliage than purple or blue. Of the seventy-one polypetalous families, forty-three contain white, forty-one yellow, and twenty-nine both kinds of flowers. White flowers are most common in families or genera containing shrubs and trees, small flowers aggregated in a dense inflorescence, and nocturnal flowers. Dark nocturnal flowers are strongly scented. Yellow flowers are more commonly herbaceous and are most abundant in the same families as white flowers, unless the species are shrubs or trees.

3. There is no evidence of the preference of beetles for flowers of any particular color. They do not avoid dull yellow. They are most common on small, white-clustered flowers with easily accessible honey and pollen. Diptera visit most frequently white and yellow flowers, but as they become more specialized and restrict themselves to flowers the percentage of visits to red and blue flowers increases. They appear to find a parti-colored, mottled, or dotted inflorescence, as in the Cruciferæ and Saxifragaceæ, attractive. Carrion flies prefer malodorous lurid-purple or flesh-colored flowers.

4. The changes of color and their sequence in individual flowers are noteworthy. Green changes to white (Cornus), to yellow (Thlaspi, Cardamine), to red (Hydrangea), to purple (Clematis), to violet (Cobæa); white changes to green (sepals of *Helleborus niger*), to yellow (Lantana), to red (Dianthus, *Hibiscus mutabilis*), to blue (many large blue flowers remain white until nearly ready to expand); yellow changes to white (Draba), to red (Æsculus), to blue (Myosotis); red changes to blue (Venetus and many Boraginaceæ); violet and blue may turn purple, green, or white in fading. The tendency of green, white, and yellow to change to red or blue is much stronger than the reverse.

5. The floral colors are often correlated with the colors of the stems and leaves, as in Sedum. The foliage of the plants with white flowers is, as a rule, paler than when the flowers contain pigments. The development of bright colors in autumn leaves presents a series of color changes, which are in part parallel to those which occur in flowers. With the disappearance of the chlorophyll the leaves become whitish, yellow, or red, according as the cells contain no pigment, or solid yellow granules, or red pigment dissolved in the cell sap. The leaves of many plants are yellowish green, due to the presence of a yellow pigment. Green, yellowish-green, and greenish-yellow flowers contain chlorophyll, and though usually small are occasionally of large size. Many white and yellow flowers are derived directly from the primitive green. White is usually a structural or optical color due to the unequal reflection and refraction of light by the intercellular air spaces and the cells devoid of pigment. White flowers are a less tax upon the energies of the plant. Flowers of all colors may revert to white, which is commonest in nature and most true to name under cultivation. If with the disappearance of the chlorophyll there is an insoluble yellow pigment in the cells, the petals are a pale yellow, and with its increase change to bright yellow or orange. The development of anthocyanin, or red pigment, dissolved in the cell sap, changes white flowers to red and yellow flowers to scarlet. With a decrease in the acidity of the cell sap the red flowers become blue. Müller's observations led him to the conclusion that the

honeybee prefers blue, violet, various shades of purple and red, to white and yellow, and avoids scarlet and lurid colors.

6. The formation of pigments is effected by the chemical composition of the soil, by altitude or the intensity of light, by latitude, and by the absence or presence of moisture, as well as other ecological forces. The particular coloration of flowers is largely a chemical problem.

The Colors of Northern Polypetalous Flowers.

Orders.	Families.	Green.	White.	Yellow.	Red.	Purple.	Blue.	Total.
	Nymphæaceæ		4	5	1	1		11
	Ceratophyllaceæ . .	1						1
	Magnoliaceæ		4	2				6
	Anonaceæ					1		1
Ranales	Ranunculaceæ . . .	6	26	38	3	13	11	97
	Berberidaceæ		3	3		1		7
	Menispermaceæ . . .	1	2					3
	Calycanthaceæ . . .					2		2
	Lauraceæ	2		4				6
	Papaveraceæ		5	10	6	2		23
Papaverales . . .	Cruciferæ	2	54	46	1	10		113
	Capparidaceæ		3	2	1	1		7
	Resedaceæ		1	2				3
Sarraceniales . .	Sarraceniaceæ			1		1		2
	Droseraceæ		4			1		5
	Podostemaceæ . . .	1						1
	Crassulaceæ	2	2	5	2	2		13
	Saxifragaceæ	4	30	6		3		43
	Grossulariaceæ . . .	4	6	1		2		13
	Hamamelidaceæ . .	1	1	1				3
	Platanaceæ	1						1
Rosales	Rosaceæ	4	35	39	13	4		95
	Pomaceæ		27		5			32
	Drupaceæ		20		1			21
	Mimosaceæ		3	1	2			6
	Cæsalpiniaceæ . . .	2	1	7		1		11
	Krameriaceæ					1		1
	Papilionaceæ		39	33	13	88	24	197
	Geraniaceæ		1		3	7		11
	Oxalidaceæ		1	6		1		8
	Linaceæ		1	6			2	9
	Zygophyllaceæ . . .			2				2
Geraniales . . .	Rutaceæ	1	2					3
	Simarubaceæ	1						1
	Polygalaceæ		3	3	2	8		16
	Euphorbiaceæ	38	9	5	1			53
	Callitrichaceæ	4						4

THE COLORS OF NORTHERN POLYPETALOUS FLOWERS.

(*Continued.*)

ORDERS.	FAMILIES.	GREEN.	WHITE.	YELLOW.	RED.	PURPLE.	BLUE.	TOTAL.
Sapindales	Empetraceæ					2		2
	Buxaceæ	1						1
	Limnanthaceæ		1					1
	Anacardiaceæ	7		1				8
	Cyrillaceæ	1						1
	Ilicaceæ		10					10
	Celastraceæ	3		1		2		6
	Staphyleaceæ		1					1
	Aceraceæ	5		3	1			9
	Hippocastanaceæ		1	3	1			5
	Sapindaceæ		2					2
	Balsaminaceæ			2				2
Rhamnales	Rhamnaceæ	5	3					8
	Vitaceæ	13						13
Malvales	Tiliaceæ		3					3
	Malvaceæ		4	5	13	4		26
Parietales	Theaceæ		3					3
	Hypericaceæ			22	2			24
	Elatinaceæ	4						4
	Cistaceæ	9		5				14
	Violaceæ		7	6		4	17	34
	Passifloraceæ		1	1				2
	Loasaceæ		2	3				5
Opuntiales	Cactaceæ	1		7	1	3		12
Thymeleales	Thymeleaceæ			1		1		2
	Elæagnaceæ			3				3
Myrtales	Lythraceæ	2				10		12
	Melastomaceæ				1	3		4
	Onagraceæ	3	14	24	10	6		57
	Trapaceæ		1					1
	Haloragidaceæ	6			1	6		13
Umbellales	Araliaceæ	2	3	1				6
	Umbelliferæ		58	16		1	3	78
	Cornaceæ	3	9	1		1		14
	Total	140	410	333	84	193	57	1217

NOTES AND LITERATURE.

ZOÖLOGY.

Shipley and MacBride's Zoölogy.[1] — It may be said in beginning that this is among the best of text-books for elementary college classes in zoölogy. It is fresh, clear, well arranged, and fairly accurate. In its first twelve pages it outlines the basal facts of zoölogy, or better of morphology, including short statements concerning life, protoplasm, and the theory of evolution, and then begins the systematic portion of the volume. The Protozoa come first; then, in order, the Cœlenterata, Porifera, and Cœlomata, — this latter division ending with man. As a result, the flatworms, rotifers, nematodes, etc., appear in the most unexpected place, — the end of the volume. There does not appear any hint that there is a question as to the validity of the cœlom or its use as a basis of classification. In the treatment of each group the authors follow the well-known English model of giving, first a detailed description of some form selected as a type, then a general statement, followed by too brief and inadequate an outline of classification.

Good as the book is as a whole, we find here and there parts which cannot have our full acceptance. In the earlier portions the authors have succeeded well in their attempt, as avowed in the preface, to produce "an elementary treatise on zoölogy which could readily be understood by a student who had no previous knowledge of the subject," but in the later portions, and especially in the treatment of the vertebrates, they fall far short of their ideal. No student, for instance, could gain from these pages, without outside assistance, any adequate idea of the skull or the nephridial system. As the whole work seems so well done, it is hardly just to publish a long list of questionable or erroneous statements which would seem to contradict the good opinion already expressed; and yet, directing attention to some of these shortcomings may lead to their correction in the subsequent editions, which will certainly follow.

[1] Shipley, A. E., and MacBride, E. W. *Zoölogy, an Elementary Text-Book.* New York, The Macmillan Company, 1901. xxi + 632 pp.

In dealing with the arthropods we object to the violent divorcing of the closely allied Crustacea and arachnids by shoving the insects between them. The conception of a crustacean head composed of five segments is unwarranted, and the retention of the group Myriapoda, in view of the work of Pocock, is indefensible, while the statement (p. 193) that Limulus occurs on our Pacific coast is erroneous. We do not believe that *Helix aspersa* is acclimated in this country to the extent implied on page 198, and on page 221 the terms "squid" and "cuttlefish" are transposed. On page 241 there is an erroneous explanation of the way in which the starfish opens clams and mussels, and we are not inclined to accept the statement (p. 221) that there are over five hundred species of Unionidæ in North America. Certainly many of the species enumerated by Conrad, Lea, and others are not entitled to any such rank.

In their account of the vertebrates the authors have attempted to carry too far homologies between the true vertebrates and the other chordate forms. For instance, the anterior head cavities of the shark cannot be compared to the proboscis cavity of Balanoglossus; and, by the way, what do the authors mean (p. 293) when they relegate the term "Balanoglossus" to the category of popular rather than generic names? On page 332 there is an erroneous conception of the pharynx, no portion of which is stomodeal; the idea of a gonotome (p. 343) has been vigorously combated, and certainly, in view of the comparatively recent researches of Rabl, the pronephric duct should not be described (pp. 342, 352), without a question, as ectodermal in origin. It certainly harmonizes with some theories, but —. Not all Dipnoi (p. 371) have two lung sacs, while some Cæcilians (*e.g.*, Ichthyophis) do have a ductus Botalii (p. 437). Again, it is certainly questionable whether Gadow's conception of the structure of a vertebra (p. 378) is correct; and the statements (p. 330) concerning the optic nerve need revision in the light of the results of Keibel, Assheton, and others, for these nerves are clearly not the stalks uniting the primary optic vesicles with the brain, but true nerves which replace them. There is also a complete crossing of the fibers in the lower vertebrates. The division of birds into Ratitæ and Carinatæ (p. 497) should not be kept up in this year 1901. In view of the statement that the vertebræ of mammals "have no cup-and-ball articulations with one another" (p. 510), we should advise an examination of the cervicals of a horse, and (p. 404) would call attention to the fact that several amphibians have amphicœlous vertebræ.

Here and there the English used is not beyond question, being sometimes inelegant, sometimes confused. The term "urinogenital" has been cast into limbo by Huxley (*Life and Letters*, Vol. II, p. 65), but language is a dangerous thing to discuss. So much depends upon the point of view, and our authors have occupied a peculiar position for seeing things, as we learn from the legend of Fig. 200, which represents the right half of a lamprey "seen from the inside of a female specimen." The mechanical part of the work is well done, and the illustrations, mostly zinc etchings, are clear, and as a rule bring out well the points made in the text.

K.

Notes. — Wallengren (*Jenaische Zeitschrift für Naturwissenschaften*, Bd. XXXVI, pp. 165–180, Taf. VII–VIII) gives a brief but interesting account of the innervation of the proboscis of some of the polychæte worms. The sense cells always occur in the papillæ of the proboscis, never on the surface between papillæ. In Nephthys and Phyllodoce they are radially arranged within a papilla, but in Glycera and Goniada they are grouped into multicellular organs, and single sense cells do not occur. In all cases the distal ends of the sense cells pierce the superficial cuticula, and in Glycera at least they end externally in a brushlike expansion. Proximally the fiber from each cell body either passes undivided to the central organs, as in Nephthys, or gives off branches at the base of the papillæ, forming a subcutaneous nerve plexus as in Glycera. No observations were made on the functions of these organs.

The ganglion cells of the electric lobes in the Torpedo are said by Hatai (*Journal Cincinnati Society of Natural History*, Vol. XX, pp. 1–12, Pl. I) to show an apparent fibrillar structure such as that described long ago by Max Schultze. Bundles of fibrils seem to enter the cell from the dendrites as well as from the neurite. This appearance, however, is due to the form of the protoplasmic reticulum, the meshes of which are much drawn out in the regions of the cell processes, and does not indicate the presence of true nerve fibrillæ. While the bundles of fibrillæ as described by Schultze are thus explained away, those discovered by Bethe and Apàthy belong to another category and probably are real structures. Gradations from the ordinary mesh work to the mesh work with fibrillar appearance have been described by Hatai in the spinal ganglion cells of the white rat.

An ingenious method of recording egg development for the use of fish culturists has been devised by C. Wallich (*United States*

Fish Commission Report for 1900, pp. 185–194). It is well known that fish eggs develop much more rapidly in warm water than in cold, and when, as is often the case, the temperature of the water at a hatching station varies from day to day, it is often difficult to estimate the stage of development reached by a given lot of eggs. This difficulty can be overcome by the use of the temperature unit system. By a "temperature unit" is meant one degree Fahrenheit above 32° F. for one day. Thus 36° F. for a day is equivalent to four temperature units. In any lot of eggs the stage of development is recorded by adding the temperature units to which they have been subjected since fertilization. The success of such a system depends upon the uniformity of its results. As judged from the experiments on salmon at the government station at Baird, Cal., the method gives a close approximation to uniformity. In something over fifty lots of salmon eggs, in which the incubation period varied from forty-eight to ninety days, the greater number of eggs hatched at about nine hundred temperature units, the extremes being 874 and 940. The utility of this method, not only to fish culturists but also to embryologists, is evident.

C. E. Beecher has contributed to the series of Yale Bicentennial Publications a volume entitled *Studies in Evolution* (New York, Charles Scribner's Sons, 1901). The volume is made up mainly of reprints selected from the publications of the Laboratory of Invertebrate Paleontology at Yale, and contains studies on the origin and significance of spines, on the structure and development of trilobites, and on the development of brachiopods. Most of the papers have already appeared in various journals, but their collection into a single volume will be welcomed by advanced students, not only as evidence of the work done at Yale, but as an indication of the new fields into which modern paleontological research is making its way.

The stony corals of the Porto Rican waters have been reported upon by T. W. Vaughan (*United States Fish Commission Bulletin for 1900*, Vol. II, pp. 289–320, Pls. I–XXXVIII). About twenty-five species are recorded and beautifully illustrated by process plates from photographs.

C. W. Hargitt and C. G. Rogers give an account of the Alcyonaria of Porto Rico (*United States Fish Commission Bulletin for 1900*, Vol. II, pp. 265–287, Pls. I–IV). Some twenty-five species are reported, of which five are new.

A descriptive catalogue of the mollusks of Porto Rico, with a check list of species, has been prepared by W. H. Dall and C. T. Simpson (*United States Fish Commission Bulletin for 1900*, Vol. I, pp. 351–524, Pls. LIII–LVIII). In all, about 650 species are recorded, of which forty-two are new. The report is illustrated by excellent figures, and has a good index.

BOTANY.

The Yearbook of the Department of Agriculture.[1] — The growing size, complexity, and activity of the national Department of Agriculture has led to attempts to simplify its publications by the establishment of series accredited to the several divisions and more or less closely pertaining to the nominal work of the latter; and a few years ago the secretary had the happy idea of confining the annual volume — before that called a *Report* — to an administrative and scientific summation of the year's work, under the title *Yearbook.* Difficulty appears to have been experienced in carrying out this idea, however, and the *Yearbook* has once more approximated its former size and character, notwithstanding the voluminous annual aggregate of bulletins and circulars published from the several divisions. In addition to the report of the secretary and an appendix of over two hundred pages, collectively constituting the report proper, the *Yearbook* for 1900 includes a biographic sketch of the late William Saunders, for many years connected with the care of the grounds and plant houses of the Department, and no less than thirty special articles, on such subjects as Smyrna fig culture, date culture, practical foresty in the southern Appalachians, etc., — all of interest and value.

T.

Britton's Manual.[2] — The most potent means of impressing ideas or facts on the public mind lies in their concrete presentation in such form as to insure ready accessibility and invite frequent reference. When, in 1892, the American botanists assembled at Rochester adopted a nomenclature codification which involved extensive changes

[1] *Yearbook of the United States Department of Agriculture*, 1900. Washington, Government Printing Office, 1901. 888 pp., 87 pls., and numerous figs.

[2] Britton, N. L. *Manual of the Flora of the Northern States and Canada.* New York, Henry Holt & Co., 1901. x + 1080 pp.

in the Latinized names of our higher plants, they insured the most rapid possible introduction of the proposed changes by taking steps for the compilation and publication of a check list in which these changes should appear; and the frequent adoption of the names approved by the authors of that list, in general and local botanical papers, and their subsequent application through the large *Illustrated Flora* of Britton and Brown, have made them generally familiar, — to the pleasure of some and the great regret of other botanists, both at home and abroad. With the changes in names have also come a change in the way of viewing species and increased attention in the field to the divisibility of species which scarcely admitted of a satisfactory knowledge from herbarium material.

To meet these needs and changed conditions the *Illustrated Flora* was prepared; and yet it was too bulky and, notwithstanding its remarkable cheapness, too costly for the fullest desirable uses. Because of these reasons, Dr. Britton, the active editor of the *Flora*, set to work to prepare a more condensed manual with the same purpose and limits as the *Flora*, and it now appears in a convenient and — for this class of book — attractive form, and is undoubtedly destined to have a wide sale and to serve a good purpose. That it will lead to a recognition of many valid species of the region covered, not recognizable by use of the familiar *Manual* of Dr. Gray, is certain, and that it will ultimately replace the latter in general use is not improbable, though the present writer would recommend the use of the two conjointly, rather than of either by itself.

T.

Vegetable Pathology.[1] — Almost from the installation of the first agricultural experiment station, the diseases of plants have been a fruitful and legitimate subject for investigation, and the selection of a station botanist has more than once hinged on his fitness to become the plant pathologist at the same time. Yet the efforts of investigators have been largely turned to the study of the life histories of parasitic fungi and the means of directly combating them, rather than to the fundamental study of pathology itself. No one who takes the trouble to read Professor Marshall Ward's presidential address before the botanical section of the British Association, delivered a few years ago, can fail to be impressed by his familiarity with the details of applied botany, and the volume before us marks a distinct advance in knowledge and points the way for the establishment of

[1] Ward, H. Marshall. *Disease in Plants.* London, Macmillan & Co., 1901. xiv + 309 pp.

an art of plant therapy, if this is ever to be possible or worth the establishment.

The Flora of Tennessee.[1] — No living botanist is as familiar with the interesting plants of Tennessee as the venerable Dr. Gattinger, who, like the late Dr. Mohr of Alabama, has spent many years in field study and now brings together the results of his work. Tennessee is a state of diversified topography, and the systematic list is preceded by a discussion of the factors which influence plant distribution. Like Dr. Mohr, Dr. Gattinger adapts himself to the Neoamerican practices in nomenclature and to the phylogenetic classification of the Germans, though not without a word of protest. Whether or not he be followed in his philosophic ideas, they contain the kernel of much that is good.

The Grasses of Iowa.[2] — In the prefatory note to this book Professor Calvin, the state geologist, tells us that the law creating the Iowa Geological Survey provides for the publication of bulletins on subjects of economic interest relating to the natural history of the state, and this consideration of one of the most important economic groups of plants forms the first of such bulletins. The topics treated are: the general structure and physiological characters of Gramineæ; purity and vitality of grass seed; cereals; fungus and bacterial diseases of grasses; the pastures and meadows of Iowa; weeds of meadows and pastures; chemistry of foods, and feeding; and lawns and lawn-making in the state. Professors Pammel and Weems are well equipped by training and opportunity for the consideration of these topics, and it is understood that the systematic discussion of the group, for which Professor Lamson-Scribner will be largely responsible, is to constitute a second volume complementary to the one now used.

Chlorophyll.[3] — No. 10 of the biologic series of *Scientia* presents in a manner not too technical for the layman the main facts concerning the chlorophyll function in plants as carried on under various external conditions. The structure, as well as the function, undergoes adaptive modifications in response to these conditions, and the

[1] Gattinger, Augustine. *The Flora of Tennessee, and a Philosophy of Botany.* Nashville, 1901.

[2] Pammel, L. H., Weems, J. B., and Lamson-Scribner, F. *The Grasses of Iowa.* Des Moines, 1901. 525 pp., 220 ff.

[3] Griffon, Ed. L'assimilation chlorophyllienne et la structure des plantes, *Scientia*, Biologie, No. 10. Georges Carré et C. Naud, Éditeurs. Paris.

author here traces these effects of the environment. Means of measuring photosynthetic activity described in the first chapter are applied to the study of this form of activity in saprophytes and parasites and to the effect of light, temperature, moisture, and mineral salts on this function in green plants having a normal nutrition. R. H. T.

Our Forests. — Popular interest in the preservation of forests is too often a matter of extremes, so diverse reasons as pure emotion or simple business considerations leading to the wish for their protection, while private greed is ever encroaching on them in the most ruthless fashion. A most attractive presentation of the subject from the æsthetic standpoint is made in a little book by G. F. Schwarz.[1] A pleasingly written commentary on a few selected trees representative of our deciduous and coniferous woods is followed by chapters on forest adornment, the distribution of American forests, the characters of the broad-leaf and coniferous forests, and the artificial forests of Europe. Throughout, the book is well illustrated by process cuts. It is neither botany nor forestry, but a delightful presentation of the beauties of nature as exemplified in forests, equally correct in treatment when viewed from either of these special points of view, and calculated to draw increased attention to the desirability of holding as tenaciously as possible to what is still left of this most charming phase of nature. T.

The Annals of the Calcutta Garden.[2] — Like its predecessors, this volume is not only well brought out, but of permanent value, and the authors, Messrs. King, Duthie, and Prain, are to be congratulated on it. The plates are lithographed, and an excellent photogravure representing *Albizzia Richardiana* serves as frontispiece. T.

Notes. — In the *Bulletin of the Torrey Botanical Club* for December Miss Eastwood describes several new Delphiniums from California.

A paper on seed coats of certain species of Brassica, including good anatomical figures, by A. J. Pieters and V. K. Charles, is published as *Bulletin 29 of the Division of Botany of the United States Department of Agriculture.*

[1] Schwarz, G. F. *Forest Trees and Forest Scenery.* New York, The Grafton Press, 1901. xiv + 183 pp.

[2] *Annals of the Royal Botanic Garden, Calcutta.* Vol. ix, pt. i, A Second Century of New and Rare Indian Plants. Calcutta, The Bengal Secretarial Press, 1901. 82 pp., 94 pls. £1 13s.

Hefte 11–12 of Abtheilung I of the 1901 volume of the *Botanische Zeitung* consists of a paper by Hannig on the septal wall of the fruit of Cruciferæ.

Professor Hildebrand contributes biological notes on *Jeffersonia diphylla* and *Apios tuberosa*, as well as other species not of our flora, to No. 8 of the current volume of *Berichte der deutschen botanischen Gesellschaft*.

Schlotterbeck and Eckler publish a paper on fruit structure and development of *Illicium floridanum* in the *Pharmaceutical Archives* for November.

The Celastraceæ of China are undergoing revision by Loesener in Engler's *Botanische Jahrbücher*, which, as usual of late, is for the most part devoted to African plants.

The development of the seed and the differentiation of the protective testa in several Sapindaceæ is discussed by Guérin in the October number of the *Journal de Botanique*.

A monograph of the leguminous genus Dorycnium, by Rikli, is published in Heft 3 of Engler's *Botanische Jahrbücher*, Vol. XXXI.

A case of parthenogenesis in Alchemilla is described by Murbeck in Vol. XXXVI of *Acta Universitatis Lundensis*, which also contains an article by the same author on chalazogamy, in connection with a further study of the same genus.

In *Torreya* for December Mr. Small publishes a new Texan cherry, under the name *Prunus eximia*.

Spiræa millefolium is figured in *Curtis's Botanical Magazine* for December.

Those accustomed to seeing *Cereus peruvianus* as it is commonly cultivated in plant houses will be interested in an open-air portrait of it as grown at Monte Carlo, published by Becker in *Die Gartenwelt* of December 21.

Opuntia monocantha, *O. glauca*, and *O. engelmanni*, which prove hardy in the botanical garden of the University of Cambridge, are figured in the *Gardeners' Chronicle* of December 7.

An illustrated account of the cacti found to be hardy in Giessen is given by Rehnelt in *Die Gartenwelt* of December 14.

The affinities of the Valerianaceæ and Dipsaceæ are discussed by Höck in Vol. XXXI, Heft 3, of the *Botanische Jahrbücher*.

In the number of the *Proceedings of the Washington Academy of Sciences* issued December 6, Mr. Coville separates from the genus Cassiope the species which have been known as *C. oxycoccoides*, *C. stelleriana*, and *C. hypnoides*, proposing for the first the generic name Arcterica, and for the last two the generic name Harrimanella, in honor of Mr. E. H. Harriman, of whose Alaskan party Mr. Coville was a member.

In *Rhodora* for November Walter Deane indicates a form *leucocarpum* for *Vaccinium pennsylvanicum*; a similarly named form for *V. corymbosum atrococcum* and a form *chiococcum* for *V. canadense* are indicated for New England.

The inelegant compound inflorescence often produced by the Edelweiss under cultivation, and which is then the despair of gardeners, is the subject of an illustrated article by Brunotte in the *Revue Générale de Botanique* of October 15.

The four United States forms of Leontodon are reviewed by Fernald in *Rhodora* for December.

In *Rhodora* for December Mr. Ames describes an artificially produced hybrid of *Lobelia inflata* ♀ × *L. cardinalis* ♂.

Euphrasia, as it occurs in North America, is reviewed by Dr. Robinson in *Rhodora* for November. *E. williamsii*, *E. randii*, *E. randii farlowii*, and *E. americana canadensis* are new names.

The west-coast Solanums of the group of *S. umbelliferum* are revised by Parish in No. 5 of the current botanical volume of *Proceedings of the California Academy of Sciences.*

For various species commonly placed in Bartonia or Mentzelia, Cockerell proposes the generic name Hesperaster, in *Torreya* for December.

Hefte 5 and 6 of Engler's *Das Pflanzenreich*, devoted respectively to Rafflesiaceæ and Hydnoraceæ by Sohns-Laubach, and Symplocaceæ by Brand, were issued November 5.

Anatomical studies of certain Australian Podalyrieæ, by Hühner, constitute Heft 3 of the current volume of the *Beihefte zum botanischen Centralblatt.*

A paper by G. N. Collins, on seeds of commercial saltbushes, constitutes *Bulletin 27 of the Division of Botany of the United States Department of Agriculture.*

A synopsis of the palms of Puerto Rico, with much extra-limital matter, by O. F. Cook, is published, with illustrations, in the October *Bulletin of the Torrey Botanical Club.*

Habit and detail figures of *Jubæa spectabilis* are published in the *Revue Horticole* of January.

In the *Bulletin de la Société Botanique de France*, Nos. 5–6 of the current volume, Gagnepain publishes a revision of the zingiberaceous genera Mantisia and Globba, as represented in the herbarium of the museum at Paris. Several new species are described and figured.

In the *Revue Horticole* of December 16 a new Pitcairnia, *P. micheliana*, from Mexico, is described and figured by André.

As No. 4 of the current botanical volume of *Proceedings of the California Academy of Sciences*, is published a revision of the genus Calochortus, by Carl Purdy.

In the November *Bulletin of the Torrey Botanical Club*, Dr. Rydberg monographs the species of his orchidaceous genera Limnorchis and Piperia, occurring north of Mexico.

The southwestern species of Sisyrinchium are passed in review by Mr. Bicknell in the October *Bulletin of the Torrey Botanical Club.*

Prof. H. Marshall Ward's handbook of grasses, recently issued from the University Press of Cambridge, is a convenient little work, with keys based on vegetative characters, leaf anatomy and fruit, as well as the more usual flower and inflorescence characters.

A paper by Holm on new anatomical characters for certain Gramineæ is published in Vol. XI, Heft 2, of the *Beihefte zum botanischen Centralblatt.*

One of the most important recent cytological papers is by Dr. Webber on spermatogenesis and fecundation of Zamia, presented as a thesis for the doctor's degree at Washington University last season, and now printed as *Bulletin No. 2 of the Bureau of Plant Industry of the United States Department of Agriculture.*

A paper by Worsdell on comparative anatomy of the Cycadaceæ forms Part II of the current volume of *Transactions of the Linnean Society of London.*

A paper on the red cedar, prepared by Dr. Mohr shortly before his death, has recently been published as *Bulletin No. 31 of the Division of Forestry of the United States Department of Agriculture.*

A specimen of *Araucaria cookii*, coning in the temperate house at the Kew Gardens, is figured in the *Gardeners' Chronicle* of November 30.

The New England form of *Lycopodium complanatum* is named var. *flabelliforme* by Fernald in *Rhodora* for November.

B. D. Gilbert publishes a note on *Lycopodium tristachyum* in *Torreya* for October.

J. H. Faull contributes an account of the anatomy of Osmundaceæ to the *Botanical Gazette* for December.

The account of the mosses of the "Belgica" expedition to the extreme South, by Cardot, occupies a quarto pamphlet of 48 pages, illustrated by 14 plates, published by the Belgian government.

Pseudoleskea artariæ and *Leskea obscura* are comparatively described by Thériot in a paper reprinted from the *Recueil de la Société Havraise d'Études Diverses* for 1901.

An extensive and well-illustrated paper on Alaskan algæ, by De Alton Saunders, constitutes No. 25 of the "Papers from the Harriman Alaska Expedition" in course of publication in the *Proceedings of the Washington Academy of Sciences.* The catalogue includes 380 species, of which 240 are new to Alaska. Nine new species and one new genus (Pleurophycus, Setchell and Saunders) are described.

Lemaire, who has been studying the micro-chemistry of the sheath of the blue-green algæ, states, in the recent numbers of the *Journal de Botanique*, that in Anabæna, Nostoc, and some other genera the mucilaginous sheath consists of a pectic compound, which, in the case of some species of Scytonema and Phormidium, is associated with another substance, which he calls "schizophycose," the latter, in some species of Scytonema, Tolypothrix, etc., being further associated with cellulose.

The Diatomaceæ of the Hull district are listed and figured in No. 4 of the *Transactions of the Hull Scientific and Field Naturalists' Club*, issued in December.

The cultivation of mushrooms is usually effected by the use of spawn either grown in mushroom beds or derived from compost piles or similar sources. In 1896 Costatin and Matruchot published interesting details of methods of securing pure and unquestionable spawn or mycelium of a few forms, and in the *Revue Générale de Botanique* of November 15 last they further describe their method of obtaining pure commercial cultures of *Tricholoma nudum*.

The modes of preserving pileate fungi without loss of their natural colors are reviewed by Lutz in the December *Bulletin de la Société Mycologique de France.*

Heft 9 of Schimper's *Botanische Mittheilungen aus den Tropen* consists of Alfred Möller's studies on Brazilian phycomycetous and ascomycetous fungi, and is fully and well illustrated.

No. 44 of the *Korrespondenzblatt des Naturforscher-Vereins zu Riga* contains a list of the twelve truffles occurring in the Baltic district.

In No. 8 of his serial *Mycological Notes*, Mr. C. G. Lloyd figures several species of Scleroderma, Geaster, and Mycenastrum.

Dr. Thaxter's epoch-marking work on Laboulbeniaceæ furnishes the text for a popular article by Mr. Massee in the November number of the *Journal of the Quekett Microscopical Club.*

The genus Fusarium, which includes several species growing on dead animal matter of various sorts, receives an interesting addition under the name *F. equinum*, described in *Science* of December 6 by Növgaard as occurring in the hair follicles and sebaceous glands of horses in Oregon.

A monograph of the genus Aspergillus, by Wehmer, is separately published from the *Mémoires de la Société de Physique et d'Histoire Naturelle de Genève*, Vol. XXXIII.

In the *Bulletin of the Torrey Botanical Club* for December, Professor Arthur publishes descriptions of a considerable number of new Uredineæ.

The effects of Rhizoctonia on the potato plant are discussed in *Science* for December 6, by F. M. Rolfs.

The fungi causing spot diseases of the cherry, etc., are discussed in an illustrated article by Aderhold in the December number of *Landwirtschaftliche Jahrbücher.*

Leaf diseases of the currant are considered by Stewart and Eustace in *Bulletin No. 199 of the New York Experiment Station.*

PETROGRAPHY.

"Perknite," a New Rock Term. — Turner,[1] in a recent article, suggests the use of the term "perknite" as the designation of coarse-grained lime-magnesia rocks composed essentially of monoclinic

[1] *Journ. Geol.*, vol. ix (1901), p. 507.

pyroxenes and amphiboles. The group of the perknites would include pyroxenites, hornblendites, and hornblende-pyroxene aggregates. It would include also websterites and similar aggregates in which monoclinic amphiboloids predominate. The augitites and some of the hornblende-picrites are the corresponding effusive types. Analyses of some of the author's characteristic perknites follow :

	SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	H_2O	Various
I.	46.28				19.54	9.91	2.21	1.89		
II.	48.04	7.82	2.01	9.32	13.33	13.01	.69	.48	3.07	2.74 = 99.51
III.	48.63	5.32	2.91	3.90	21.79	13.04	.34	.23	2.81	1.16 = 100.13
IV.	50.80	3.40	1.39	8.11	22.77	12.31	tr	tr	.52	.73 = 100.03
V.	53.25	2.80	.69	5.93	19.91	16.22	.19	tr	.29	.70 = 99.98
VI.	53.21	1.94	1.44	7.92	20.78	13.12	.11	.07	1.01	.87 = 100.47

I. Hornblendite. Dyke near Silver Peak Village, Esmeralda County, Cal.
II. Amphibole-pyroxene rock. Abundant in Mariposa County, Cal.
III. Perknite (peridotite). Belchertown, Mass.
IV. Pyroxenite. Johnny Cake Road, Baltimore, Md.
V. Websterite. Mt. Diablo, Cal.
VI. Websterite. Oakwood, Cecil County, Md.

Shonkin Sag; A Study in Differentiation. — Shonkin Sag is a flat laccolite rising from the plains southeast of the Highwood Mountains, Montana. It has afforded Weed and Pirsson[1] excellent opportunities for the study of the differentiation of a magma in place, since it is dissected by a stream valley formerly occupied by a branch of the Missouri River. Examination of the sections exposed to view indicate that the igneous portion of the laccolite consists of concentric shells of leucite-basalt, skonkinite, a transition rock composed of groups of large augite crystals and long slender foils of biotite with white feldspathic material between, and syenite, with the last-named rock in the center. The various rock types grade into one another without discernible breaks between them. The facts suggest to the authors "that the body of the magma forming the laccolite must have been injected as a whole, in a homogeneous condition, and that the rearrangement and formation of the various parts followed within the mass itself. . . . The first stages of cooling and crystallization against the outer envelope of sedimentary rocks was relatively more rapid than that affecting the inner portion, and resulted in producing the outer porphyritic shell." There was, further, a gradual withdrawal and concentration of feldspathic material toward the inner portion of the mass and an enrichment of the outer zone with lime, iron, and magnesia, thus producing the concentric arrangement of the rock types.

[1] *Amer. Journ. Sci.*, vol. xii (1901), p. 1.

Basic Rocks in Maryland. — A series of acid and basic rocks intrude the gneisses of northeastern Maryland, and these in turn are cut by extensive dykes of granite and pegmatite. The principal types are biotite granite, diorite, tonalite, norite, hypersthene-gabbro, pyroxenite, peridotite, and serpentine. The order of eruption seems to have been norite and gabbro, diorite and granite. The last two rocks are connected by gradation phases, and this is thought to be evidence that their difference in age is not great. The peridotites and pyroxenites are mainly younger than the norites and gabbros, but some of the pyroxenites are apparently peripheral phases of the norite.

The succession taken as a whole is supposed to "furnish an example of the occurrence of several rock types which represent the facies of a single magma and unite to form a geological unit."

The serpentines were derived partly from the peridotites and partly from the pyroxenites. In the latter change the hypersthene and diallage first alter into fibrous hornblende, and this later passes into the serpentine. The area is very similar in its essential features to the Delaware area of gabbros described by Chester and the Baltimore area described by Williams. The distinguishing features of the present area are (1) the abundance of diorite, (2) the comparative rarity of gabbro-diorite, and (3) the great abundance of pegmatite and granite dykes.[1]

Rock Structure. — The study of a series of andesitic and rhyolitic rocks that occur as extrusives in the Great Basin region suggests to Spurr[2] that the differences in structure of igneous masses may be brought about by slight changes in conditions under which crystallization took place. Among the differences which affect structure may be mentioned slight changes in the rate of cooling. Textural variations are less common in acid than in basic extrusives because in the latter the viscosity varies more rapidly with rapid cooling than in the former. The more important structures are not characteristic of particular rocks, but are the functions of the relation between viscosity and cooling rate. Structure therefore cannot, according to the author, be made the principal element in rock classification.

[1] Leonard, A. G. *Amer. Geol.* (1901), p. 135.

[2] *Journ. Geol.*, vol. ix (1901), p. 586.

CORRESPONDENCE.

To the Editor of the American Naturalist:

SIR: — In that very interesting and not unimportant book *Memoirs of Odd Adventures, Strange Deliverances, etc., in the Captivity of John Giles, Esq. . . . written by himself*, describing his captivity among the Indians of New Brunswick in 1689–98, occur many quaint but truthful remarks upon the habits of common animals. But among the others occurs this:

Of the Tortoise. It is needless to describe the fresh-water tortoise, whose form is so well known in all parts: but their manner of propagating their species is not so universally known. I have observed that sort of tortoise whose shell is about fourteen or sixteen inches wide. In their coition they may be heard half a mile, making a noise like a woman washing her linen with a batting staff. They lay their eggs in the sand, etc.

I have asked several students of these animals for information about the noise here mentioned, but none of them seem to know it. Giles (or more properly Gyles) is usually so accurate in his observations that I can hardly believe he was wholly mistaken in this case. Can any of the readers of the *American Naturalist* throw any light upon the subject?

The immediate reason for my interest in the matter is an inquiry from my friend Mr. Victor H. Paltsits, of the Lenox Library, New York City, who is editing and exhaustively annotating a new edition of Gyles's Memoirs, soon to be published by Dodd, Mead and Co. of New York.

W. F. GANONG.

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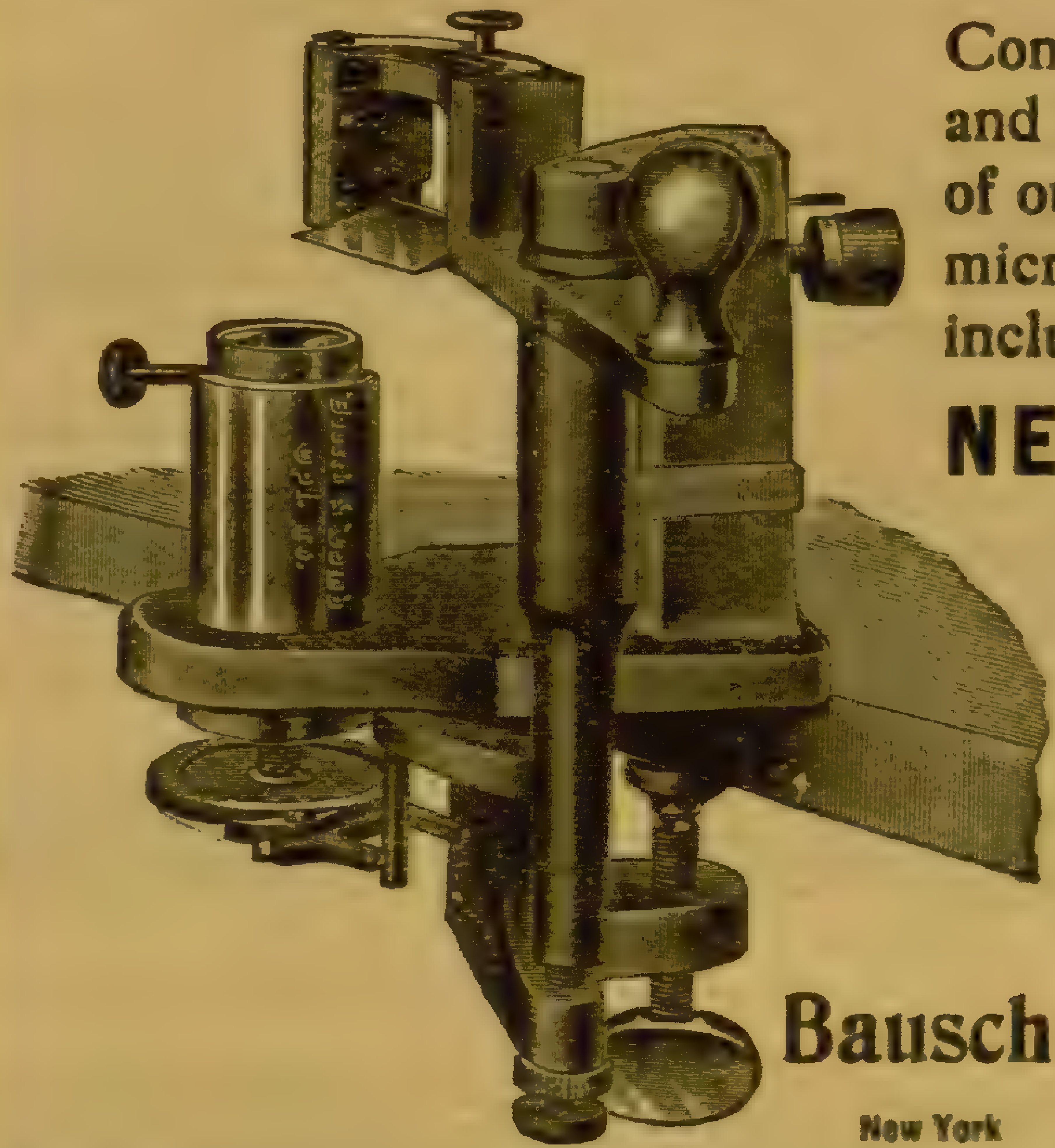

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HOMOPLASY AS A LAW OF LATENT OR POTENTIAL HOMOLOGY.

HENRY FAIRFIELD OSBORN.

My study of teeth in a great many phyla of Mammalia in past times has convinced me that there are fundamental predispositions to vary in certain directions; that the evolution of the teeth is marked out beforehand by hereditary influences which extend back hundreds of thousands of years. These predispositions are aroused under certain exciting causes and the progress of tooth development takes a certain form converting into actuality what has hitherto been potentiality.

Science, N.S., Vol. VI, No. 146 (Oct. 15, 1897), pp. 583–587.

In previous communications, as shown in the above quotation, I have spoken of the "potential of similar variation," as covering cases of the independent evolution of identical structures in the teeth of different families of mammals, especially in relation to the homologous "antecrochet" and "crochet" folds in the teeth of horses, rhinoceroses, and we may now add, of titanotheres (Osborn, **'94**, p. 208). In the present communication I propose to treat somewhat more fully of the same phenomenon, as a special form of homology which has been clearly defined by Lankester in 1874 as *homoplasy*, but into which paleontology has brought the idea of "potential."

THE BROAD SIGNIFICANCE OF ANALOGY.

We are familiar with the classic distinction of analogous organs as having a similarity of function: *analogy* (Owen, '43, p. 374), "a part or organ in one animal which has the same function as another part or organ in a different animal"; Lankester ('70): "Any two organs having the same function are analogous, whether closely resembling each other in their structure and relation to other parts or not; and it is well to retain the word in that wide sense." Analogous organs may or may not be homologous. "Analogy" is therefore an extremely broad and comprehensive term, and it appears that we must include under it all cases of the similar evolution of organs either of common or of different origin due to similarity of function. For example, the "analogous variation" of Darwin, the "homoplasy" of Lankester in part at least, the "convergenz" of German writers, the "homomorphy" of Fürbringer, the "heterology," "parallels," and "parallelism" of Hyatt, of Cope ('68, also *Origin of the Fittest*, p. 96), of Scott, and of most American writers, are all illustrations of analogy and may be very misleading as to homology.

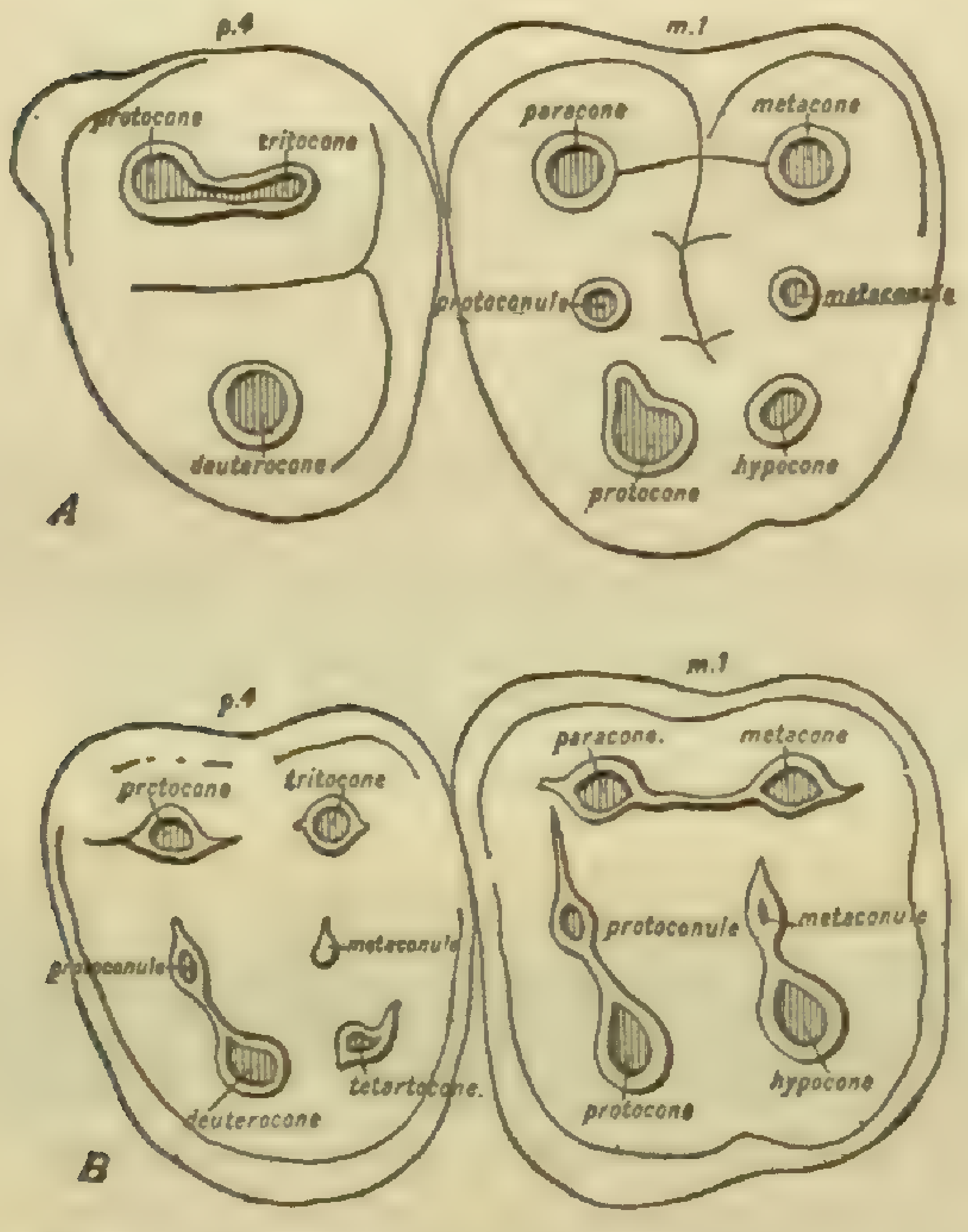

FIG. 1.— Fourth upper premolar and first molar of primitive ungulates. *A*, Euprotogonia; *B*, Hyracotherium. Not believed to be genetically related, yet exhibiting independent or homoplastic evolution of homologous cusps.

As Scott observed in 1896, "Parallelism[1] and convergence of development are much more general and important modes

[1] The term "parallelism" was employed by Cope in his essay of 1868 on the "Origin of Genera" (reprinted in the *Origin of the Fittest*) in two quite different senses: first, in relation to recapitulation in ontogeny,—"Those which accomplish less [stages] are *parallel* with the young of those which accomplish more [stages]; second, quite in the modern sense (*op. cit.*, pp. 96–104) of independently acquired resemblances in different groups. As employed by Scott in his essay

of evolution than is commonly supposed. By parallelism is meant the independent acquisition of similar structure in forms [*i.e.*, animals] which are themselves nearly related, and by convergence such acquisition in forms [*i.e.*, animals] which are not closely related, and thus in one or more respects come to be more nearly alike than were their ancestors."

The term "homoplasy" (Lankester) has been long used by the writer and others in a somewhat similar sense, but it is not equivalent either to "parallelism" or "convergence." As will be seen below, the fundamental idea is different, because homoplasy always involves homology, while parallelism and convergence may or may not involve homology.

Analogy in Evolution.

Analogy.

- *Analogous Variation* (Darwin). Similar congenital variation in more or less distantly related animals and plants.
- *Parallelism.* Independent similar development of related animals, plants, and organs.
- *Convergence.* Independent similar development of unrelated animals, bringing them apparently closer together.
- *Homoplasy* (Lankester) (? *Homomorphy*, Fürbringer). Independent similar development of homologous organs or regions giving rise to similar new parts.

In brief, analogy embraces similar changes due to similar adaptation in function both in homologous and in non-homologous organs, both in related and in unrelated animals.

The Limited Significance of Homology.

Owen ('**43**, p. 379), Lankester ('**70**), and Fürbringer have especially defined and elaborated the very ancient conception of homology, as employed by Oken, Geoffroy St. Hilaire, and Vicq d'Azyr : *homology* (Owen, '**43**), "the same organ in

"On the Mode of Evolution in the Mammalia" ('**91**, pp. 363–367), "parallelism" is used in a very broad sense as affecting the skeleton and teeth, on the principle "that identical modifications of structure, constituting evolution of types, have supervened on distinct lines of descent," as embracing not only single characters but whole series of them.

different animals under every variety of form and function"; *homogeny* (Lankester, '70): "Structures which are genetically related, in so far as they have a single representative in a common ancestor, may be called *homogenous*." E. B. Wilson ('95, pp. 101–124) has shown that the comparative anatomical test of homology is more reliable than the embryological. Gegenbaur ('98, pp. 23–25) has given a full presentation of the distinctions as the basis of comparative anatomy; in his recent great work ('98, p. 23) he presents the matter in terms which may be briefly analyzed with the usages of other authors, as follows:

I. HOMOLOGY, GENERAL: as of vertebræ and limbs.

1. HOMOTYPY: as of opposite limbs, eyes, kidneys, etc.
2. HOMODYNAMY: (in part the "general," in part the "serial," homology of Owen; the "meristic" homology of Bateson). Corresponding limbs, parts, segments (*e.g.*, the humerus and femur) on the same side of the body.
3. HOMONOMY: parts which are in the same transverse axis of the body, or on only one section of the longitudinal axis; *e.g.*, the rays of the fins of fishes, the single fingers and toes of the higher vertebrates are homonomous organs.

II. HOMOLOGY, SPECIAL: (the "homogeny" of Lankester).

1. COMPLETE HOMOLOGY of elements which have retained their relations unchanged, as of single bones from the Amphibia to the Mammalia.
2. INCOMPLETE HOMOLOGY, as of organs which have either gained new parts or lost certain of their parts.
   a. *defective*, as in comparison of fins of teleosts and of selachians.
   b. *augmentative*, as in the heart of cyclostomes and of the higher vertebrates.
   c. *imitative*, as where different vertebræ connect with the ilium and become sacral.

III. HOMOMORPHY (Fürbringer): from these homologies certain structures are to be distinguished as *homomorphic* which are more or less similar to each other but stand in no phylogenetic connection.[1]

Homomorphy comes nearest, as we understand it, to the "homoplasy" of Lankester, but the latter term has the priority of definition.

[1] Literally translated from Gegenbaur.

Distinction between Homogenous and Homoplastic Organs.

In the strictest sense, special or genetic homology, the "homogeny" of Lankester, is the only absolute homology. For example, in all four-limbed vertebrates, or Tetrapoda (Credner), the first and second phalanges of the tibial digit or hallux are homogenous; the earliest tetrapods had such phalanges, so far as we can judge from both paleontology and embryology, and all others are derivatives.

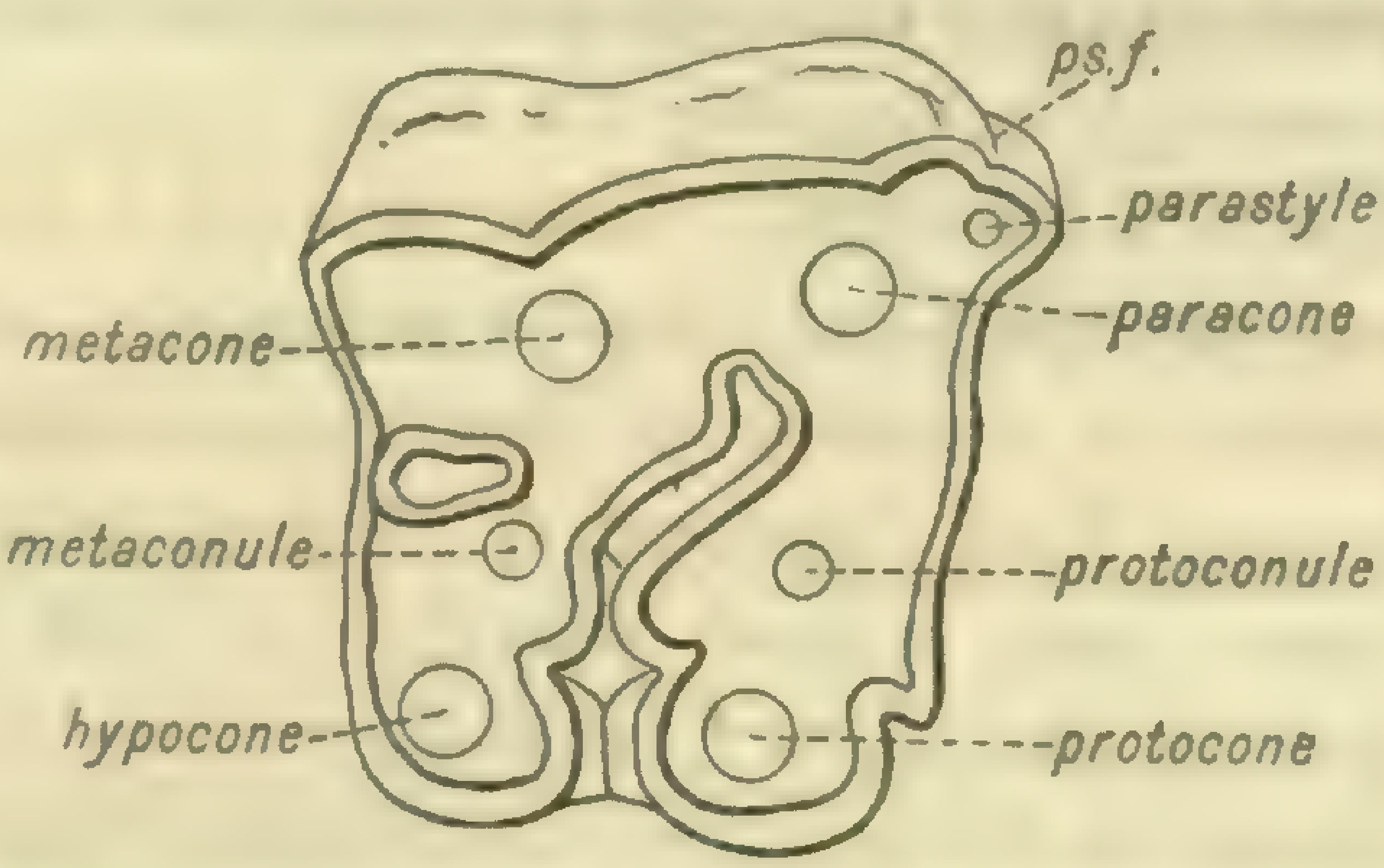

Fig. 2. — Ideal embryonic ground plan of rhinoceros molar, showing relation of primitive cusps to the folds and crests.

But suppose we should discover that these two phalanges had originated independently in several different classes of vertebrates, and were not derivatives; should they then be considered analogous or homologous? "Again," says Lankester ('70), "it may perhaps be admitted that the common ancestors of the Osseous Fishes and Mammalia had a skull of decidedly undifferentiated character, with a much less amount of differentiation than is observed in the skulls of either of these groups. It is only in so far as they have parts represented in the common ancestor that we can trace *homogeny* in these groups; and yet the *homology* of a vast number of bones in the skull of the two is discussed and pointed out." Suppose, accordingly, that in the formation of dermal roofing bones in different orders of fishes a pair of bones corresponding in position to the parietals should arise

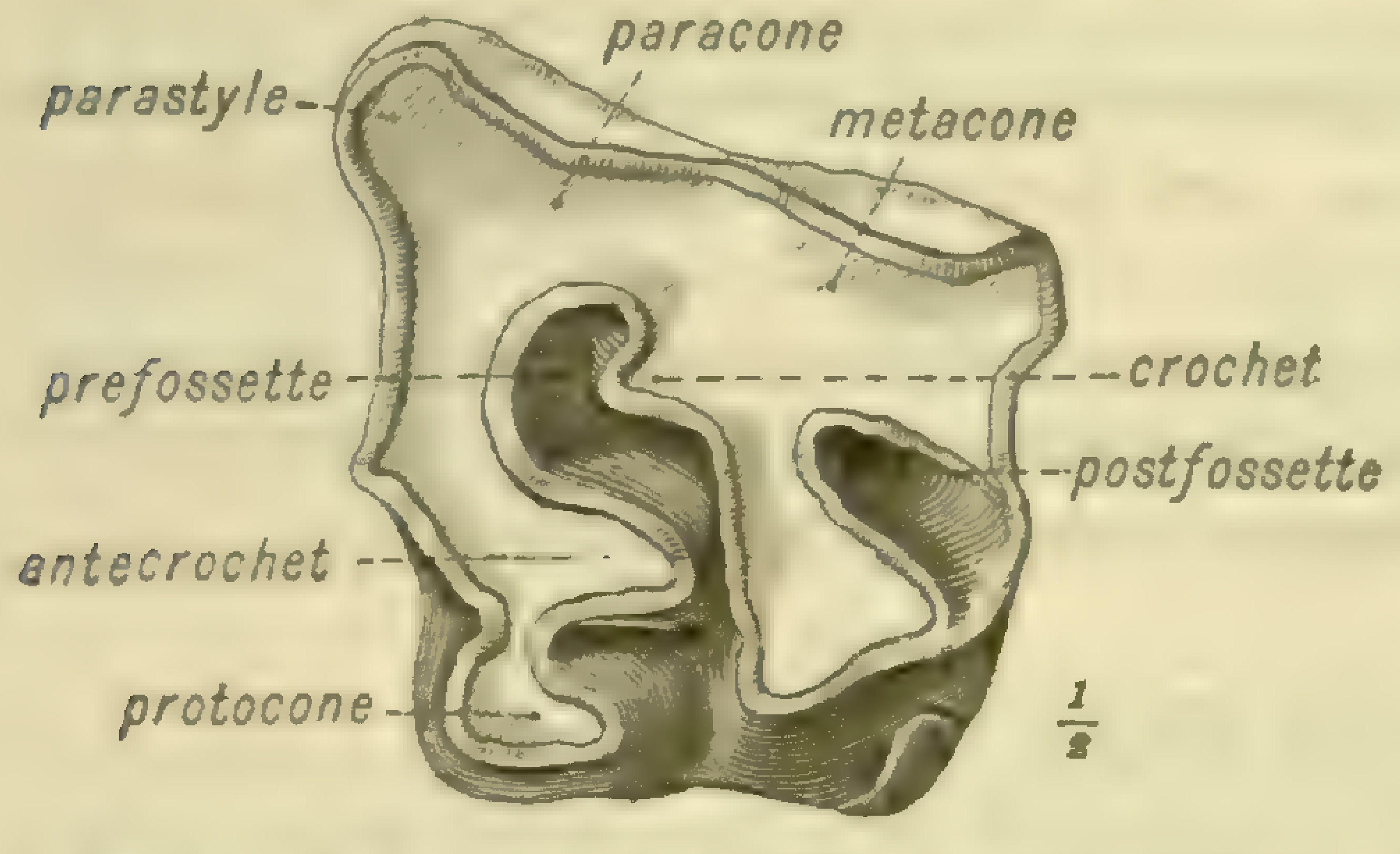

Fig. 3. — Molar tooth of an Upper Miocene rhinoceros (Teleoceras), showing origin of secondary folds.

independently, or that in the evolution of the teeth cusps should arise independently having the same form and position, — what criterion should be applied? All such structures are habitually regarded as homologous, yet it is apparent that they are not derivatives of each other and therefore not homogenous or homologous in the strictest sense.

Such cases of independent evolution of apparently homologous organs I recently proposed[1] to signify as *potential*, or *latent homology*, borrowing the term "latent" from Galton as indicative of a germinal rather than of a patent or adult character, and the physical term "potential" as expressing the innate power or capacity to develop a certain organ. But my colleague, Prof. Edmund B. Wilson, pointed out to me that such cases were almost exactly covered by the *original definition* of the word "homoplasy" by Lankester ('70, p. 42), as shown in the subjoined quotations from his essay:

> When identical or nearly similar forces, or environments, act on two or more parts of an organism which are exactly or nearly alike, the resulting *modifications*[2] of the various parts will be exactly or nearly alike. Further, if, instead of similar parts in the same organism, we suppose the same forces to act on parts in two organisms, which parts are exactly or nearly alike and sometimes homogenetic, the resulting correspondences called forth in the several parts in the two organisms will be nearly or exactly alike. I propose to call this kind of agreement *homoplastic* or *homoplasy*.[3] . . . What is put forward here is this: that under the term "homology," belonging to another philosophy, evolutionists have described and do describe two kinds of agreement, — the one, now proposed to be called "homogeny," depending simply on the inheritance of a common part; the other, proposed to be called "homoplasy," depending on a common action of evoking causes or moulding environment on such homogenous parts, or on parts which for other reasons offer a likeness of material to begin with.

Homology thus includes { Homoplasy. / Homogeny.

It follows that subsequent writers, including myself, have misused the term "homoplasy," confusing it with "parallelism"

[1] In a communication before the National Academy of Science, Nov. 13, 1901.

[2] Italics are mine.

[3] At this time Lankester accepted Herbert Spencer's Lamarckian views. Subsequently he abandoned the mechanical inheritance theory for the pure natural selection theory.

and "convergence," which, as we have seen, may affect absolutely non-homologous structures. *Homoplasy should be confined to structures in which there is an element of homology.*

Independently of Lankester (that is, not familiar with his paper) I had therefore reached a similar conclusion through years of observation in paleontology. I would now like to expand an idea which he also lightly suggested in 1870 in the words, "*or on parts which for other reasons show a likeness of material to begin with.*"

The Law of Homoplasy as in Part Identical with Definite or Determinate Variation.

As observed in the evolution of the teeth especially, homoplasy appears to be of very great importance, not on the technical grounds of uniformity in nomenclature, but because it seems to coincide with the principle of definite or determinate evolution, a principle which may be of wider application.[1]

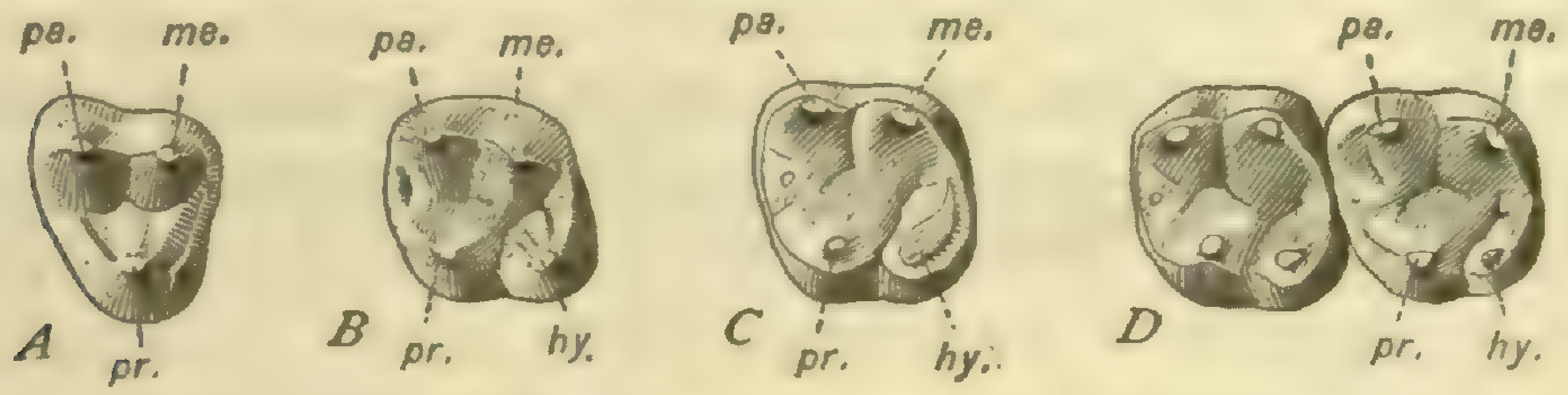

Fig. 4.—Superior molars of primates, Anaptomorphus to Homo, showing independent or homoplastic origin of the hypocone, *hy*, from the cingulum.

From the time of the "Origin of Species" it has been admitted that evolution, so far as it depends upon variation, is not in every possible direction, but is limited to certain changes, the expression of certain hereditary or constitutional causes which we do not in the least understand. The evolution of the teeth of mammals enabled me in 1889 to give many concrete illustrations of this principle and to show that variation is hardly the proper term to apply to rudiments which do not arise in a variable but in a fixed manner.

[1] See especially the correspondence of Darwin and Asa Gray; also Osborn, The Palæontological Evidence for the Transmission of Acquired Characters, *Nature*, Jan. 9, 1890; the Orthogenesis and Orthoplasy of Eimer, Lloyd Morgan and Baldwin; Baldwin's *Dictionary of Philosophy and Psychology*, vol. i, p. 243.

It appears that von Waagen suggested the term "mutation" for immeasurable variations somewhat similar to these. Scott in 1891 ('**91**, p. 388) pursued the idea further in the following striking passage: "These facts at least suggest the possibility that individual variations are not incipient species, but that the

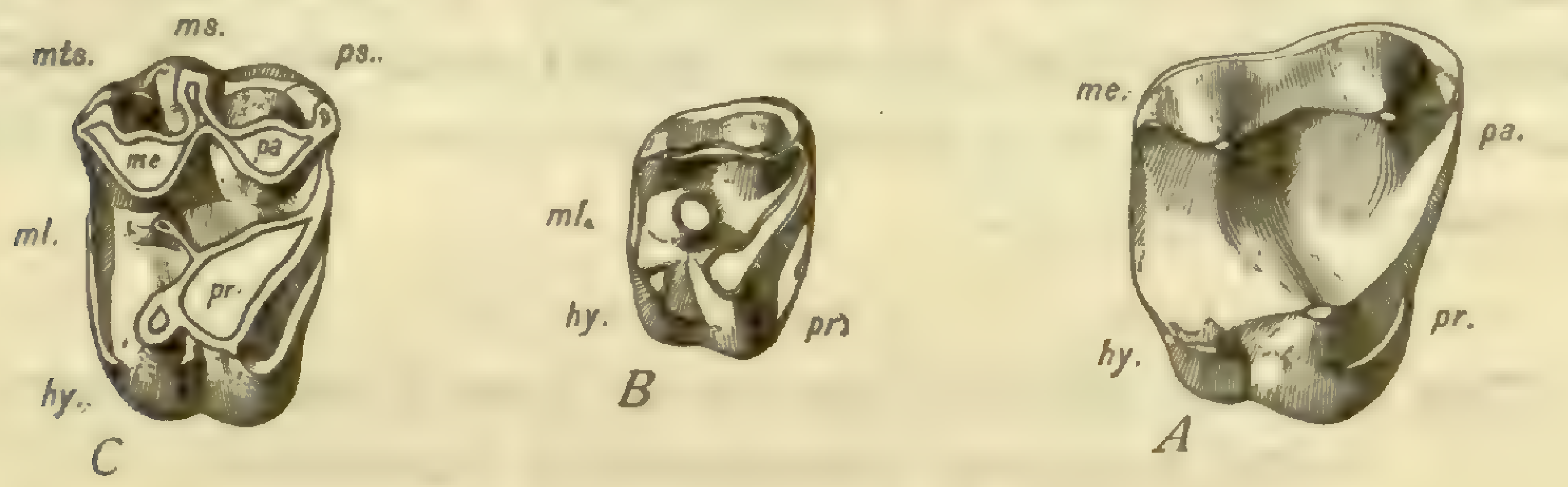

FIG. 5.—Superior molars of primates. *A*, Adapis; *B*, Hyopsodus; *C*, Notharctus. Showing homoplastic cusps, *hy*, *ml*, *ps*, *ms*, *mts*.

causes of transformation lie deeper, and act with more or less uniformity upon large numbers of individuals. It may, perhaps, be the outcome of future investigations, that while variations are generally due to the union of changing hereditary tendencies, mutations are the effect of dynamical agencies operating long in a uniform way, and the results controlled by natural selection. While this *may* be true, a great many facts must be gathered in its support, before it can be regarded as more than a suggestion." Scott subsequently, in his article "Variations and Mutations," expanded this idea: "Bateson's results, as compared with those of paleontology, confirm this distinction in many significant ways and emphasize strongly the difference between variation and that steady advance along definite lines which Waagen called mutation." This paper in turn is said to have influenced de Vries's recent work, *Die Mutationstheorie*.

It is a singular coincidence that the human teeth were selected by both Empedocles and Aristotle to test the "survival of the fittest" *versus* the purposive or teleological theory of evolution. I pointed out in the papers above referred to (Osborn, '**89**, pp. 561–566; '**90**) the significant fact that new cusps of the molar teeth do not appear at random, but at certain definite points; that they are at first so minute that

they can barely be perceived, so that it is difficult to theoretically assign them a survival value in the struggle for existence; that the mechanical or Lamarckian explanation is the only one which can be offered[1]; I laid the chief stress, however, not upon the mechanical explanation, but upon definite or determinate origin, and this has been confirmed by the subsequent study of thousands of teeth in different families of mammals. The still more significant fact that this definite and determinate evolution was proceeding independently in a great many different families of mammals did not at the time impress itself so strongly upon my mind.

If molar teeth are found independently evolving in exactly similar ways in such remote parts of the world as Switzerland, Wyoming, and Patagonia, it is obvious that the process is not governed by chance but represents the operation of some similar or uniform law deduced from the four following considerations:

Firstly, the teeth differ from all the other tissues and organs of the body in being preformed, beneath the gum.[2] Unlike all other organs they are not modified, improved, or rendered more adaptive by use; on the contrary, after the first stage of wear,

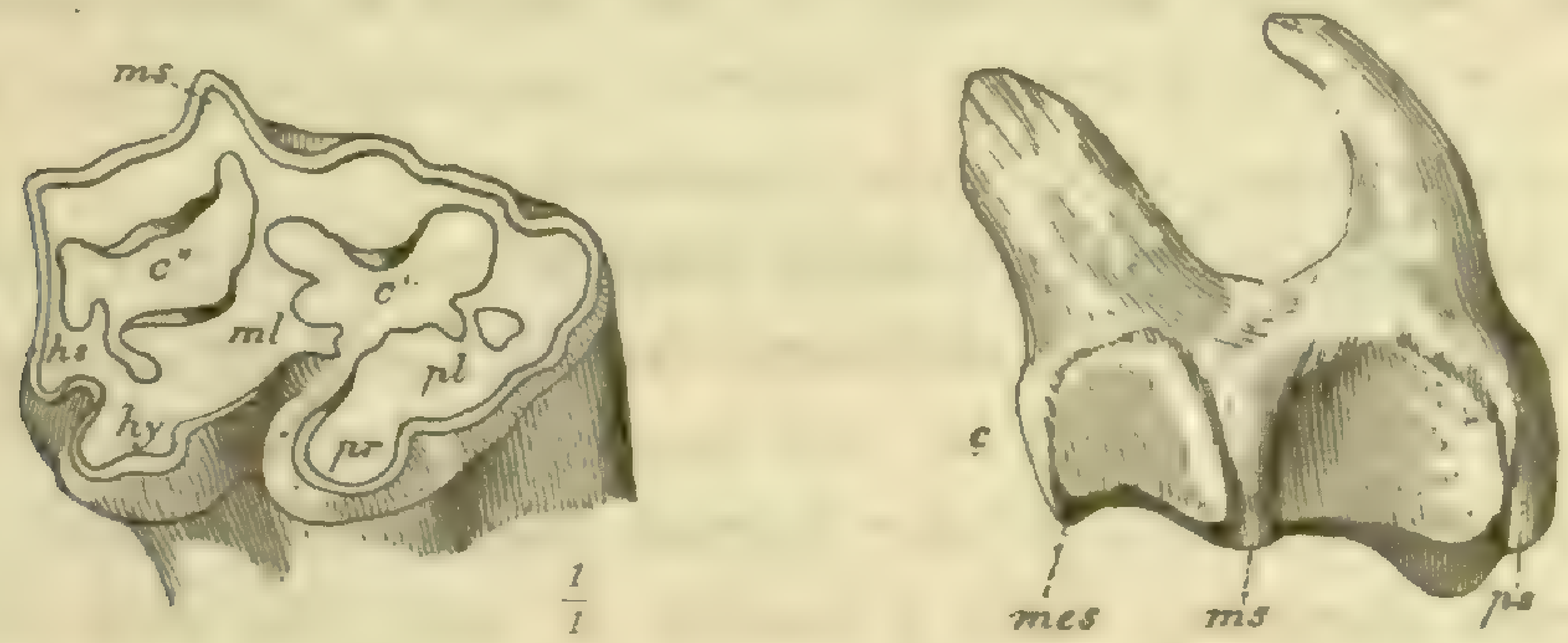

Fig. 6. — Superior molar of Merychippus, showing styles *ps*, *ms*, *mts*, and conules *pl*, *ml*, homoplastic with those of the wholly unrelated primate molar, Fig. 5, *C*.

the longer they are used the more useless and less adaptive they become. Thus, new structures in the teeth do not first appear as *modifications* (as distinguished from congenital

[1] Ryder and Cope confidently advanced the mechanical explanation; it is not without grave difficulties, owing to the lack of an heredity theory.

[2] The importance of this fact was first pointed out to me by Prof. E. B. Poulton of Oxford.

variations) in course of life, as is so often if not invariably the case with new structures in the skeleton. New cusps, folds, crests, and styles are invariably congenital. Thus, of all organs of the body the teeth most exclusively and purely represent the current of stirp, germinal, or constitutional evolution.

Secondly, the teeth are, nevertheless, among the most progressive organs in the body. Whereas the adaptation of the skeleton, among the mammals at least, is by a constant loss or numerical reduction of parts, the adaptation of the teeth is by a constant addition and modeling of parts (Osborn, '88, pp. 1067–1079).

Thirdly, according to the present paleontological evidence many of the different families and orders of mammals diverged from each other at a time when they possessed three cusps on the upper molar teeth and from three to five cusps on the lower molar teeth. This being the case, only the cusps comparable in different orders of mammals with these original three upper and five lower cusps are derivatives or homogenous.

Fourthly, it follows that the new cusps of the teeth furnish an example of homoplasy independent of the individual modification.

Thus, we may say that in the teeth at least *homoplasy involves a law of latent or potential homology*, without professing to understand what is its significance.

We should, *a priori*, expect that if additional cusps were added independently in different families and orders of mammals in different parts of the world, under highly different conditions, the teeth of the higher Mammalia would present very great diversity. As a matter of fact, the new cusps in different families are absolutely uniform up to a certain limit.[1] In the twenty-three orders of placentals and in the seven marsupial families, many of which are adaptively equivalent to orders, the independently developed fourth to eleventh cusps of the upper molars, if so many are developed, are uniform and may be termed homologous; the eight cusps and folds succeeding the original homogenous three arising, if at all,

[1] The excess of this limit is in multituberculism, or polybunodonty, where cuspules are indefinitely multiplied.

at similar points and presenting a latent homology or homoplasy. The record in the upper molar teeth stands thus :

HOMOLOGY.

HOMOGENY	HOMOPLASY
Primitive three cusps common to all mammals.	Cusps or folds which are or may be independently developed in different orders.
Protocone	Hypocone
Paracone	Metaconule
Metacone	Protoconule
—	Parastyle
—	Mesostyle
—	Metastyle
—	Protostyle
—	Hypostyle

This expresses the comparison of mammals as a whole. Within many of the orders, such as the Perissodactyla, which arise from six cusped ancestors, the homology is different.

HOMOLOGY.

HOMOGENY	HOMOPLASY
Protocone	Parastyle
Paracone	Mesostyle
Metacone	Crista
Hypocone	Crochet
Protoconule	Antecrochet, etc.
Metaconule	—

The elements to which these terms are applied are best exemplified in the molar teeth of some of the primitive horses (Fig. 6).

The teeth are by no means the only structures which evolve under this principle, the skull, vertebral column, and limbs also evolving under it more or less completely; but the teeth afford a singularly beautiful illustration of it because they exclude individual modification.

The chief object of this communication is to enforce the recognition of homoplasy as something which must be accounted for. These homoplastic cusps do not arise from selection out of fortuitous variations, because they develop directly and are not picked from a number of alternates. Neither does it appear that the mechanical-inheritance theory, if granted, would produce such a remarkable uniformity of result. We are forced to the conclusion that in the original tritubercular constitution of the teeth there is some principle which unifies the subsequent variation and evolution up to a certain point. Herein lies the appropriateness of Lankester's phrase, "a likeness of material to begin with."

Philosophically, predeterminate variation and evolution brings us upon dangerous ground. If all that is evolved in the Tertiary molar tooth is included in a latent or potential form, in the Cretaceous molar tooth we are nearing the *emboîtement* hypothesis of Bonnet or the archetype of Oken and Owen. Embryologists have recently gotten into the same dilemma, and my colleague, Wilson, has proposed to drop the idea "homology" altogether and substitute the idea "equivalent." In the present case, however, I think we have to deal with homology or, more strictly, with a *principle intermediate between homology and analogy*.

In a paper recently read before the American Morphological Society (December, 1901), this author has urged the necessity of adhering as closely as possible to the historical standard in the embryological study of homology, and of avoiding the use of the term "homology" when this standard is not available. He therefore suggests for descriptive purposes the use of the noncommittal terms "equivalent" and "homoblastic," the former being applied to embryonic structures of like fate (*i.e.*, giving rise to homologous parts), the latter to those of like embryonic origin. The only decisive test of the homology is historic community of derivation (*i.e.*, homogeny).

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NEW INSTANCES OF COMPLETE DIVISION OF THE MALAR BONE, WITH NOTES ON INCOMPLETE DIVISION.

ALEŠ HRDLIČKA.

THE malar bone in man, and also among lower mammals, is found occasionally to present a partial or a complete division.

The complete malar divisions are in general rare; the incomplete ones are rare in most of the species of the lower mammals, but are quite common in man. Both varieties of the divisions occur with unequal frequency in the different races of man, and, seemingly, even in different localities in the same people.

The first case of a complete malar division in man was described in 1779 by Ed. Sandifort.[1] Since then the anomaly has been observed among most of the principal branches of the whites and also among the Japanese, Aïnos, Chinese, Buriats, Bashkirs, Burmans, natives of the Malay Archipelago and of the Philippine Islands. The most important contributions to the literature of the subject are those by Breschet,[2] Wenzel Gruber,[3] and Virchow[4]; other authors who occupied themselves with malar divisions are Amadei,[5] Flesch,[6] Riccardi,[7]

[1] *Observat. Anat. Pathol.* Lugd., Batav., 1779. Vol. iii, 8, p. 113. Cit. Gruber.

[2] Recherches sur différentes pièces osseuses du squelette de l'homme et des animaux vertébrés, *Ann. d. Sci. Natur.*, Sér. 3, tome i, p. 25. Paris, 1844.

[3] Monographie über das zweigetheilte Jochbein, etc., Wien, 1873; five additional publications on the subject in *Arch. f. Anat. u. Phys.*, 1873, p. 208; 1875, p. 194; 1876, p. 230; and in *Arch. f. pathol. Anat. u. Phys.*, 1877, Bd. lxix, p. 382; and 1879, Bd. lxxvii, p. 113.

[4] Über die ethnologische Bedeutung des os malare bipartitum, *Monatsberichte d. k. preuss. Akad. d. Wiss.* Berlin, 1882, p. 230.

[5] *Arch. p. l' antropol. e l' etnolog.*, 1877, p. 11.

[6] Über das zweigetheilte Jochbein, *Verhandl. d. phys.-med. Ges. in Würzburg*, 1877, pp. 51, 52.

[7] Suture anomale dell' osso malare, *Arch. p. l' antropol. e l' etnolog.*, tomo viii (1878), pp. 1 *et seq.*

Hilgendorf,[8] Tarenetzkij,[9] Calori,[10] Matiegka,[11] etc. In other mammals cases of complete malar division have thus far been found in two *Cercopitheci sabæi* (Laurillard,[12] Breschet[2]); in four *Mycetes seniculi* (Laurillard, Breschet); in one *Mycetes niger* (Breschet); in an orang (Flesch[6]); in a hippopotamus (Breschet); and in a *Phascolomys wombatus* (Gruber[3]).

The complete malar divisions present some variety. In a very large majority of the cases, both in man and the lower mammals, the malar was found divided into two portions by a suture running antero-posteriorly from the malo-maxillary to the zygomatic articulation. In the orang described by Flesch the posterior extremity of the anomalous division terminated on the temporal border of the malar bone, a short distance anterior to the upper end of the zygomatic suture. In two of Calori's cases the posterior termination of the anomalous suture was situated respectively at the base and above the middle of the ascending portion of the temporal border. The second of these cases shows much similarity with one I have at hand, in which the malar division is due to fracture (*v.* the end of this paper).

Testut reports a case[13] in which the division ran in a curve from the ascending portion of the orbital border to the middle of the malo-maxillary suture. Spix,[14] Breschet,[2] Riccardi,[7] and Ruggeri,[15] finally, observed a division of the malar into three portions, the location of which differed in each instance.

Of incomplete malar divisions there have been described thus far only horizontal ones in which the suture connects with either the zygomatic or the malo-maxillary suture.

[8] *Arch. f. patholog. Anat. und Phys.*, Bd. lxx (1879), pp. 113 *et seq.*

[9] Beiträge zur Craniologie der Aïnos und Sachalin, *Mém. de l'Acad. Imp. Sci. de St. Pétersbourg*, Sér. 7, tome xxxvii (1890), p. 39.

[10] Su le anomalie dell' osso zigomatico, etc., *Mem. d. R. Accad. d. Sci. dell' Istit. d. Bologna*, Ser. 5, tomo iii (1893), p. 415.

[11] Prvni Lebka z Čech s "Os Malare Bipartitum," *Věstnik Král. České Společ. Náuk*, vol. xxviii, pp. 1–24. Prague, 1899. Also in German.

[12] In Cuvier's *Leç. d'Anat. Comparée*, 2d ed., tome ii (Paris, 1837), pp. 385, 386. Çit. Gruber.

[13] *Traité d'Anatomie Humaine*, tome i, p. 174. Paris, 1889.

[14] *Cephalogenesis s. capitis ossei structura, formatio et significatio* (Monachi, 1815), p. 13. Cit. Gruber.

[15] Un osso zigomatico tripartito, *Rivista Sperim. di Treniatria*, tomo xxiii (1897), p. 460; refer. *Centralbl. f. Anthropol.*, Bd. iii (1898), p. 20. Cit. Matiegka.

The presence of a malar division is generally held to signify a non-fusion of the original centers from which the bone developed. It is not yet definitely settled whether there are usually two or three of these centers. According to Breschet the malar bone develops in the majority of cases from one, in a smaller number of instances from two, and occasionally from three centers of ossification. Gruber was of a similar opinion. Rambauld and Renault, on the other hand, advanced the theory that the malar develops always from three points of ossification. In the words of these authors (*Origine et dévelopment des os* (Paris, 1864), pp. 161, 162, Atlas, Pl. XIII, Figs. 4, 5), "nous l'avons (l'os malaire) toujours vu s'ossifier par un seul centre, mais composé de trois points." "Ces points . . . apparaissent de très bonne heure et se réunissent très-vite." "Vers le milieu, et plus souvent à la fin du second mois, l'os malaire est composé de trois points." The subject is much in need of further embryological investigation.

Nothing is known as to the immediate causes of the anomaly and but little as to its signification.

The meaning and importance of the incomplete divisions will be considered later.

New Testament of Complete Malar Division.

The new cases of complete malar division which came under my observation comprise one instance of the anomaly in a white adult woman, one in an adult male Peruvian (prehistoric), a bilateral division in an orang and in a Lagothrix, and a unilateral one in a Cercopithecus, a Mycetes, and a bear. In detail, these cases are as follows:

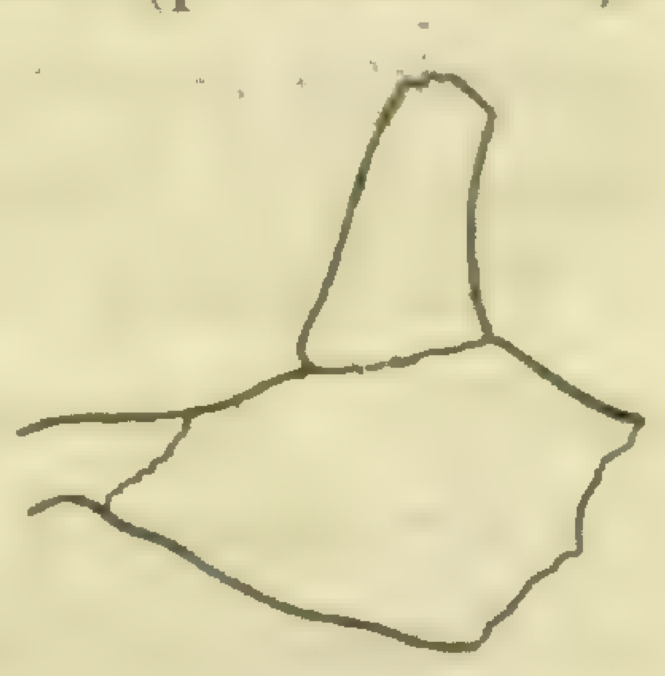


Fig. 1

Case I (Fig. 1). — The first specimen consists of a part of the face, including the right malar, of a white adult female, found by me among the unidentified bones in Professor Huntington's osteological collection in the College of Physicians and Surgeons (Medical Department, Columbia University), New York City.

The malar bone shows remnants of an anomalous division, which separated the frontal process from the body of the bone.

The division runs in the line of the posterior or horizontal position of the temporal border of the malar and consists of a row of small, irregular perforations, with a larger, round foramen in the middle. It is plain, on both the anterior and posterior surfaces of the bone, that the line of openings is the remnant of a former complete separation of the frontal process.

There are no signs of injury. The part of the face with the left malar has not been recovered. The right malar shows no further abnormality.

The malar division in this specimen is analogous with the superior of the two divisions in the case described by Riccardi, and is considered by Matiegka, whom I informed of the case, to represent a non-union of the superior of three centers from which the bone developed.

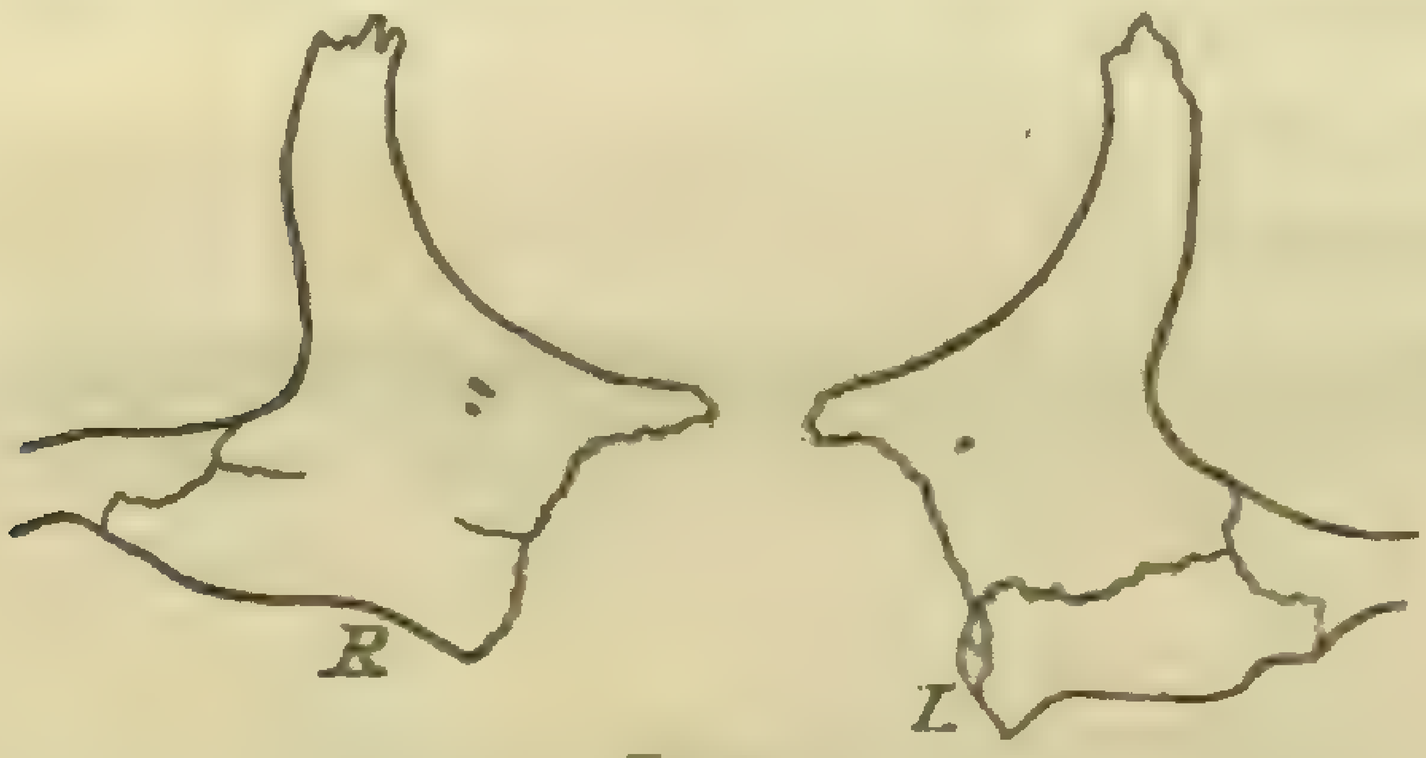


FIG. 2.

Case 2 (Fig. 2). *Malar Division in a Peruvian.* — This is the first instance of a complete malar division found among aboriginal Americans. It is the only skull with a complete division that I found among 492 old-Peruvian and over 2000 other Indian crania from various localities. The specimen is one of the Bandelier collection, in the American Museum of Natural History, New York City.

The skull is that of a male of between forty and fifty years of age. It is of a moderate size, and shows nothing extraordinary except a moderate artificial frontal compression and a persistence of the metopic suture.

The left malar presents a complete and patent, horizontal, serrated suture, which divides it into a narrow lower, and large upper, portion. The right malar shows in a similar location a 0.5 cm. long, straight, anterior, and a 0.7 cm. long, slightly serrated, posterior, incisure.

The two malars differ considerably in size, the left one being higher, but narrower, than the right one.

	Left.	Right.
Highest point of fronto-malar suture vertically downward to the anomalous suture,	4.2 cm.	——
Highest point of fronto-malar suture vertically downward to lower edge of the malar,	5.2 cm.	4.4 cm.
A line between the most superior point of the malo-maxillary and the zygomatic suture,	3.7 cm.	3.9 cm.
A line between the most inferior point of the malo-maxillary and the zygomatic suture,	2.7 cm.	3.2 cm.

This excess in height and deficiency in breadth of the fully divided malar when compared to its mate is in full accordance with previous observations on this point. A relative narrowness of the inferior of the two portions of the divided malar is also more the rule than the exception.

The incisures in the right malar have apparently influenced the growth of that bone but little. The evidence of the measurements is against their equivalence with the complete division on the right. If these incisures are remnants of a complete division, the measurements indicate an early union of the middle portion of the malar.

The presence of the frontal division has apparently no relation to that in the malar bone. A persistent metopic suture is present in 97 of the 492 Peruvians, without there being another case of a complete malar division; there is also in these skulls no excess of malar incisures.

Fig. 3.

Case 3 (Fig. 3). *A Bilateral Complete Malar Division in an Orang.* — The skull is that of a young orang and is a part of a mounted skeleton in Professor Huntington's museum in the College of Physicians and Surgeons, New York City. Besides the malar divisions the specimen shows nothing unusual.

The malar sutures are in every way much alike on the two sides. They run each with a moderate double curve from near

the middle of the malo-maxillary to very near the superior termination of the zygomatic suture. Both divisions are slightly serrated.

The right malar bone is slightly higher than the left one, but the frontal process and to a less extent the body of this latter is broader.

The situation of the malar sutures in this case is similar to that in the orang described by Flesch; the posterior termination of the division in Flesch's case lay, however, still somewhat higher, terminating on the temporal border of the malar, slightly anterior to the zygomatic suture.

Case 4 (Fig. 4). *A Unilateral Complete Malar Division in a Cercopithecus callitrichus.* — Among the forty skulls of Cercopitheci in the zoölogical collection of the American Museum of Natural History, New York City, there is one with a complete and one with a partial malar division.

FIG. 4.

The skull with the complete division belongs to an adult female, *C. callitrichus* (No. 13,923), and shows besides the malar also a bilateral parietal division.

The malar division is found on the left only; there is no trace of a similar anomaly on the right side.

The malar suture begins anteriorly at a point between the lower and middle thirds of the malo-maxillary articulation, runs backward parallel with the inferior border of the malar, and terminates in the curve of the temporal border of the bone, 0.8 cm. anteriorly to the upper end of the zygomatic suture.

The divided malar is in whole higher than the undivided one (l. 2.9 cm., r. 2.4 cm.), and its frontal process is broader; but the bodies of the two bones are of very nearly the same dimensions.

The lower separate portion is relatively narrow.

Neither in this nor in any of the preceding cases is there an extension of any process of bone from the zygoma to the maxillary.

The case of a partial malar division in a Cercopithecus (Fig. 5) may be conveniently described in this connection. The skull showing this anomaly is that of an adult animal of unknown

sex and variety. It is free from other abnormalities. The division occurs in the right malar bone. It begins distally in the deepest portion of the curve of the temporal border of the bone, is somewhat curved, well serrated, and extends forward to the middle of the body of the bone. It is equally pronounced on the anterior and posterior surface of the malar. The divided bone is externally very slightly higher than the other malar, and its body is slightly narrower.

Fig. 5.

Case 5 (Fig. 6). — The skull of an adolescent male *Lagothrix humboldti* (specimen No. 6333, American Museum of Natural History, New York) shows a bilateral, antero-posterior, complete malar division. Anteriorly the division begins on each side slightly below the middle third of the maxillary border of the bone and from this point runs horizontally backward, to terminate on the temporal border of the malar. The posterior termination of the division reaches to within one millimeter of the superior portion of the zygomatic suture on the left and to within two and a half millimeters of the same on the right side. Both the anomalous sutures are serrated. They show both much better dorsally than ventrally. In this specimen there is on each side but a slightly incomplete temporo-maxillary arc. The large malar foramina (regular in these monkeys) are situated well above the divisions. The two malars are very nearly of equal size, except anteriorly, where the right bone is slightly higher.

Fig. 6.

The skull shows no other anomalies, nor anything pathological. In three other skulls of monkeys of the same variety the malars are normal.

Case 6 (Fig. 7). — Among twelve skulls of Mycetes, in the American Museum of Natural History, there is one (No. 14,169) which shows a complete unilateral malar division.

The skull with a complete division is one of an adolescent male *M. alouata*, and is otherwise in every respect normal.

The division affects the left malar. It begins anteriorly slightly above the lower third of the maxillary border of the bone and runs, with some serration, backward, very nearly parallel with the inferior border of the malar, to the zygomatic suture near its superior termination. Ventrally the division is covered by a broad temporo-maxillary arc.

FIG. 7.

The right malar is normal. It is both lower and narrower than the left bone, and even the zygomatic arch is lower on the right.

MEASURES.

	LEFT.	RIGHT.
Height along the maxillary border,	2.0 cm.	1.85 cm.
Width at middle (width minimum),	0.6 cm.	0.55 cm.
Height of temporal process vertically, from the superior end of the zygomatic suture,	0.8 cm.	0.65 cm.

In a skull of Mycetes, in the same collection, there is in each temporal border of the malar, slightly anterior to the zygomatic suture, a short incisure, directed forward.

Besides those already mentioned I have examined, for malar divisions, the skulls of 6 Lemurs, 5 Nictipitheci, 31 Cebi, 10 Ateles, 1 *Silenus vetur*, 16 Cercocebi, 1 Senmopithecus, 54 Macaques, 4 Mormons, 1 Innuus, 2 Cynopitheci, and 16 Cynocephali, — all in the collection in the American Museum of Natural History. Among these specimens there is none with complete and only a few with incomplete malar divisions. Of these latter only the following one deserves to be mentioned in this place.

Cynocephalus olivaceus (No. 10,747; Fig. 8). — The left malar shows a faint and only dorsally visible, incomplete, serrated suture, running from a point a very little above the lower third of the maxillary border of the bone to the malar foramen. The length of the suture is 1.1 cm. The right malar shows traces of a similar division. The two malars are almost exactly equal.

FIG. 8.

This case differs from any thus far on record. The exact nature of the division is uncertain.

Case 7, Unilateral Malar Division in a Bear. (No. 4282, American Museum of Natural History; Fig. 9). — The division affects the left malar of a young American black bear (incisors and canines not yet replaced by teeth of the second dentition).

Dorsally only the superior third of the division is open, the other portion of it being secluded but still traceable; ventrally the anomalous suture is patent in its entirety.

The division begins anteriorly considerably below the middle of the malo-maxillary articulation and runs in almost a straight

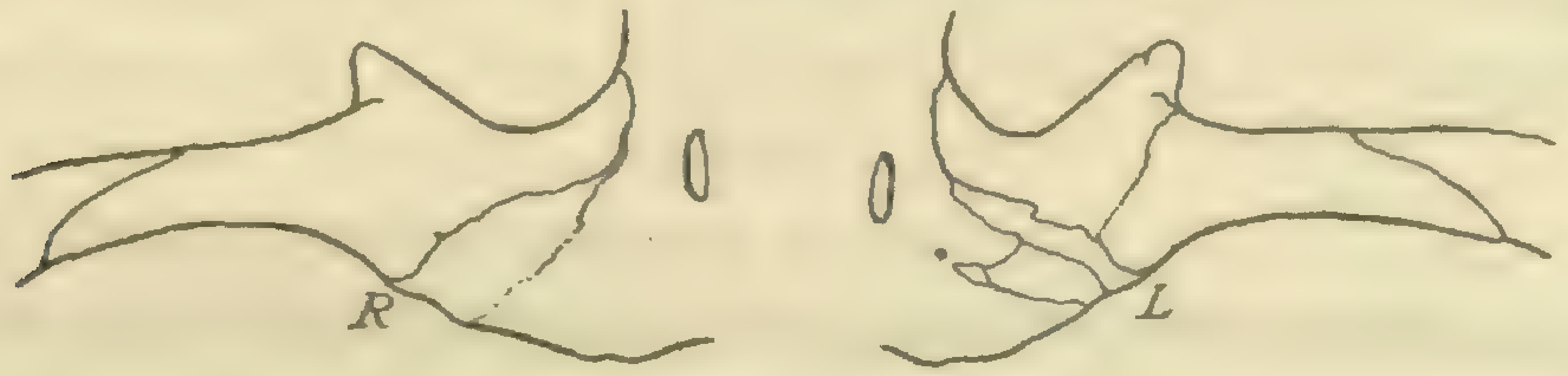


Fig. 9.

direction upward and slightly backward, to the base of the frontal process. The suture shows a slight serration.

The frontal process of both the malars is partly detached. The right malar shows a small anterior incisure in a location corresponding to the antero-inferior terminus of the division on the left. Finally, there are on the left one small bone and two larger, oblong ones, and on the right one large, oblong osside, intercalated between the antero-inferior two-thirds of the malar and the superior maxilla.[16]

The two malars show but little difference in size.

The above specimen is one of twenty young adolescent and young adult skulls of bears of the same variety preserved in the American Museum of Natural History. No other of these skulls presents a complete malar division similar to that in No. 4282; several of the specimens, however, show an anterior malar incisure, visible on the internal surface of the bone. Besides this almost all the specimens present more or less of a separation of the frontal process of the malar. In four of the

[16] A similar bone has been found in man by Gruber (*Arch. f. Anat., Physiol.*, etc. (1873), p. 195, Pl. V, Fig. 1). See also Breschet.

skulls the separation of the process is complete, in two bilaterally and in one on one side. The following figure shows one of these instances; in this case there is not only a complete separation of the frontal process, but also a superior incisure, running in a similar direction to the anomalous suture in the young bear (No. 4282; Fig. 10).

Separations of the frontal process, such as the one just pictured, have been observed in the seal and walrus (Meckel, Pander, d'Alton, Hallman, Köstlin, cit. Gruber; the condition is present in a number of young seals in the collection in the American Museum of Natural History); they remind one of the superior division of the malar in Riccardi's case and the one similarly situated in the first case reported in this paper.

FIG. 10.

The division of the body of the malar bone is, as shown in the bear (No. 4282), independent of the separation of the frontal process. This latter appears in the bears as an epiphysis of a comparatively late formation.

It is interesting to note that the posterior termination of the malar suture, situated somewhat higher in the orangs, is placed still higher, relatively, in most of the specimens in lower monkeys and other mammals. This condition is very marked in the Cercopithecus and especially in the young bear. The cause of this lies, it seems to me, not so much in a different situation of the centers from which the malar develops, as in the different tilting of the bone, and in the differences in the temporal process, in man and the mentioned animals. The human malar bone is less tilted than that in bears, and its temporal process is considerably shorter and relatively broader than that of apes, monkeys, and bears, as well as other mammals.

PARTIAL MALAR DIVISION.

The anterior and particularly the posterior portion of the malar shows occasionally a partial division. These divisions occur mostly in the form of lineal incisures, but occasionally also as serrated sutures. They differ much in length, in some

cases not exceeding one or two millimeters, in others extending to near the middle of the malar. In man they run as a rule in an antero-posterior direction, beginning distally from either the zygomatic or the malo-maxillary suture.

The posterior divisions are in the average more pronounced and much more frequent than the anterior ones. An anterior and a posterior partial division may coexist in the same bone, and there is a tendency, though there are exceptions, to similar divisions on the two malars.

There is a considerable difference in the frequency of these partial malar divisions in different peoples. They are found in the adults of both sexes, but grow more rare as age advances; they are, according to my data, somewhat more frequent in early than in adult life.

These malar incisures are well known, but their meaning is still somewhat doubtful. Gruber, who was the first to give these divisions close attention, considered them as morphologically distinct from the complete separations. In the words of this author (*Virch. Arch.*, Bd. LVII, 1879, p. 117), "*os zygomaticum bipartitum* is a term applied only to that malar bone which is fully divided into two portions and persists thus divided after the second month of the fœtal life, as well as after birth; or to that malar, which was originally fully divided, but in which the anomalous suture became later (in adult life), in consequence of synostosis, more or less occluded." "When [*ibid.*] in a fœtal malar bone, through a hindrance in development (Bildungshemmung), the streaks between the orbital and maxillo-zygomatic portion of the bone do not on one or both sides ossify, and this defect of ossification persists, in the form of an incisure, into advanced age, leaving thus a sort of a *sutura mendosa*, in that case one evidently cannot speak of a divided malar."

This apparently clear and rational theory was three years later opposed by Virchow.[1] This author expresses himself (p. 251) as "inclined to recognize the majority of all malar incisures, particularly the posterior ones, as real remnants of an old transverse malar suture"; but (p. 252) "the interpretation of a posterior incisure will be the more doubtful, the higher the situation of the incisure."

Both Gruber's and Virchow's opinions gained adherents, and in the absence of decisive embryological investigation the matter is still unsettled.

The significance of the partial malar divisions can be actually demonstrated only by studies on the embryo. Nevertheless, the examination of older subjects brings out a few points from which, it seems to me, it is possible to draw a few deductions having a bearing on the nature of these divisions.

Such points are the size of the incisures, their somewhat greater frequency in childhood than in adult life, and the lack of correspondence in frequency between the incomplete and complete divisions in childhood in general or in the adults of different ethnic groups.

All the points mentioned speak *against an exact equivalence* of the partial and complete malar divisions and for Gruber's theory. Were all or a majority of the incisures remnants of formerly complete separations of the malar, it is reasonable to suppose that we should, even if rarely, meet with a remnant of the separation that would extend over more than a half of the bone; and it would be logical to expect a greater frequency of complete divisions in early than in later life and in those tribes or races in whom the incisures are more common than in others. As these conditions *are not realized* we must search for another explanation for the incisures. This explanation can be found, as already pointed out by Gruber, in the analogies of the development of the malar with other cranial bones, particularly the occipital, or the parietal.

The parietal bone will, I think, serve the demonstration even better than the occipital. The bone develops, as was shown by Toldt and Ranke, from two superimposed centers of ossification, — a very similar process to that which undoubtedly takes place in the body of the malar, though this bone may possibly develop from more than two original points. The two centers of the parietal have but a very brief separate existence. They grow in all directions and very soon coalesce. Their union takes place at their reciprocally most advanced portions, in the middle, the parts anterior and posterior to this point of fusion remaining separated by a more or less V-shaped space or fissure.

This fissure, as the bone grows, gradually closes at its proximal extremity, but becomes extended, by the new bone, at its distal end. The result of this is that even as late as at the birth of the human fœtus the parietal bone shows a more or less marked posterior, and rarely also an anterior, partial division, exactly analogous with, it seems to me, though almost generally less persistent than, the malar incisures. The parietal division may persist even up to adult life and then the analogy between the same and a malar incisure is still closer. The difference between this form and a complete division (or a remnant of such) in either the parietal or the malar is that in the simple incisure and fissure we have before us only a *retardation* of the union of the distal portions of the original segments of the bone, while in the complete division (or its remnant) we are confronted with a case of a complete non-union and *separate development* of these segments. The two effects may be produced, and probably are produced in such a case as that in the Peruvian skull with a complete malar division on one and two incomplete ones on the other side, by different degrees of the same cause ; nevertheless they cannot be considered identical. The cause which induces a separate development of all or some of the centers of ossification of a bone must be potent and be present extremely early ; a persistence of a fissure might be due to a weaker cause of the same nature, but possibly also to later causes of differing kind. The complete divisions deserve fully the term "anomalies," or "atypical formations," while the partial divisions come more under the category of developmental defects or retardations.

The partial malar divisions are not attended by similar conditions in other bones of the skull. They also do not seem to stand in any relation with the metopic division ; specimens with the frontal suture in my Peruvian series have, upon an additional inspection, shown no greater percentage of malar incisures than other skulls in the same collection.

There is nothing in the appearance of the partial divisions, except, perhaps, their size, which would allow us to differentiate them from *remnants* of complete malar sutures. Should a division extending beyond the middle of the bone be found, it

would then be safe, I think, to consider it a remnant of a partly occluded complete suture. Tarenetzkij [17] would distinguish the incisures from remnants of complete divisions by the greater height of the malar in which a complete division had existed than that of its mate, but such a criterium, though theoretically seemingly correct, meets in practice with numerous difficulties. Not many malars, even though entirely free from divisions, are exactly equal. The presence of partial divisions, especially when large, is probably not without influence on the size of the bone. Where a complete suture had existed but became early subject to partial obliteration, the size of the malar was undoubtedly less affected than in the cases where the suture remained patent until more advanced life. Finally, where a bilateral complete division existed, if obliteration on the two sides proceeded simultaneously, the malars would be liable to be of a very nearly equal size, and the indications of a complete suture would be absent; or, had the occlusion proceeded with much difference in time, the two malars would be unequal, and we should be predisposed to consider only the incisures in the larger malar as the remnants of a complete suture.

Actual measurements bear out well the uncertainty of basing any conclusions upon the difference in the size of the malars. Taking at random one hundred skulls of Peruvians of both sexes, in whom both malars were well preserved and the malar articulations were free from any signs of occlusion, I measured the dimension of the malar mostly affected by a transverse division, namely, the height of the body of the bone. The measurements were taken with a sliding compass at the middle of the bone, parallel with the malo-maxillary suture. Among the one hundred skulls there were seventy-two in which the malars showed no division, sixteen in which both malars showed a posterior incisure,[18] four in which the right, and seven in which the left, malar presented a posterior incisure, and one in which both malars showed both posterior and anterior incisures. The results of the measurements, which hardly need any comment, will be found in the table on the opposite page.

[17] Tarenetzkij. *Mém. de l'Acad. Imp. de Sci. de St. Pétersbourg*, tome xxxvii, No. 13 (1890), p. 39. [18] Only lineal incisures above 1 mm. in length considered.

	Equal.	Larger by 0.5 mm.		Larger by 1 mm.		Larger by 1.5 mm.		Larger by 2 mm.		Larger by 2.5 mm.		Larger by 3 mm.	
		Left.	*Right.*	*Left.*	*Right.*	*Left.*	*Right.*	*Left.*	*Right.*	*Left.*	*Right.*	*Left.*	*Right.*
1) Malars with no division	29	6	5	10	9	5	2	1	1	0	2	2	0
2) Both malars with a posterior incisure .	3	3	1	0	3	3	0	2	0	1	0	0	0
3) Right malar with a posterior incisure .	1	0	0	1	0	0	0	0	0	1	1	0	0
4) Left malar with a posterior incisure .	3	0	2	1	0	0	0	0	1	0	0	0	0
5) Both malars with an anterior and a posterior incisure	0	1	0	0	0	0	0	0	0	0	0	0	0

Résumé :

	Equal.	Left Malar Higher.	Right Malar Higher.
1)	29	24	19
2)	3	9	4
3)	1	2	1
4)	3	1	3
5)	0	1	0

The incomplete malar divisions occur in whites, according to various authors,[19] with the following frequency:

Gruber found the posterior incisure among 4000–5000 mainly Russian skulls in 428, or 8.5 to 10.7% and among 50 skulls of children and embryos in 7, or 14%.

Meyer found the incisures among 517 German skulls in 20, or 3.9%; among 42 Russian skulls in 3, or 7.1%.

Tarenetzkij found the incisures among 45 French skulls in 2, or 4.4%; among 416 Russian skulls in 28, or 6.7%.

Anutschin (source and kind of incisures not stated) in 1.2%.[20]

Matiegha found among 300 Czech skulls the posterior incisures in 22, or 7.3%; in anterior incisures in 6, or 2.0% of the cases.

All the authors who examined various ethnic crania for the partial malar divisions (Meyer, Sarasin, Tarenetzkij, Anutschin, Koganei, etc.) found them to be more frequent in almost all other peoples (Australians excepted, Anutschin) than in the whites.

In the human skulls that I have examined for this condition the partial malar divisions were distributed as shown in the tables on pages 290 and 291.[21]

The data given on these pages show plainly:

1. A considerably greater frequency of partial malar divisions in the American aborigines than in the whites. This excess in the partial is not associated with any corresponding excess in the complete divisions.

2. The divisions among the American aborigines occur relatively more frequently in the females than in the males and most frequently in children; however, the differences in the percentages in these three groups are not excessive.

3. The posterior divisions greatly preponderate in frequency over the anterior ones.

4. Both the anterior and posterior incisures are much more frequently bilateral than unilateral.

[19] In part after Matieghka.

[20] Has unusually low percentages with all the groups examined — apparently some individual peculiarity in recording.

[21] Only plainly marked incisures above one millimeter in length counted. All skulls in which there were signs of synostosis in the malar articulations were excluded. The material examined belongs to the collections of the American Museum of Natural History and the College of Physicians and Surgeons, New York City.

No malar incisures were found in the Australians and Polynesians. Among the various American tribes, the largest proportions of the incisures were found among the Peruvians and the Southern Utah Cliff Dwellers, but in general the data on the Americans, or at least those on the better represented tribes, show a considerable agreement.

In mammals below man malar incisures appear to be very rare. However, I found some instances of the condition in monkeys and a bear. The cases in monkeys, besides those mentioned, are as follows:

Cynocephalus porcarius (No. 10,277, *A. M. N. H.*). — The left malar shows dorsally a marked anterior incisure, beginning in the maxillary border of the bone a short distance above the antero-inferior angle and directed obliquely upward and backward.

The skull of a young Cynocephalus (No. 135, *C. P.* and *S.*) shows on each side an anterior malar incisure somewhat similar in location and direction, but smaller, particularly on the right, to that in the preceding case.

In a *Cercocebus mona* (No. 5025, *A. M. N. H.*) a 0.5 cm. long, horizontal incisure divides slightly above its middle the temporal process of the left malar.

The subject of partial malar divisions could be finished here were it not for two other forms of incisure which are met with on the bone.

The first of these incisures, already mentioned, is the one which occurs at the base of the frontal process of the malar in some animals. It is common in younger American bears; it is also occasionally found in seals and other pinnipeds, but is rarely seen in other classes of mammals. This division is a remnant of a complete separation of the frontal process of the malar; no analogous incisure has been found thus far in man, apes, or monkeys.

The second special form of partial malar division seems to occur only in man. It consists of a more or less marked, vertical, or more often somewhat oblique, frequently bilateral incisure, which runs downward from some part of the malo-frontal suture. So far as I can find, this incisure has not yet

No. of Skulls.		Sex.	Anterior Incisures.			Posterior Incisures.			No Incisures.
			Right only.	*Left only.*	*On Both Sides.*	*Right only.*	*Left only.*	*On Both Sides.*	
72	Whites	M.	—	—	—	4, or 5.6%	3, or 4.2%	6, or 8.3%	59, or 81.9%
50	"	F.	—	—	—	1, or 2%	—	2, or 4 %	47, or 94%
5	"	Children	—	—	—	1, or 20%	—	—	4, or 80%
10	African Negroes	M.	—	—	—	—	—	1, or 10%	9, or 90%
6	" "	F.	—	—	—	1, or 16.7%	—	—	5, or 83.3%
9	Australians and Polynesians. .	M.	—	—	—	—	—	—	9, or 100%
11	" " " . .	F.	—	—	—	—	—	—	11, or 100%
	Americans:								
4	Esquimaux	M.	—	—	—	—	—	1, or 25%	3, or 75%
2	"	F.	—	—	—	—	—	1	1
2	"	Children	—	—	—	—	—	—	2
17	Northwest Coast Indians . . .	M.	—	—	—	—	—	3, or 17.6%	14, or 82.4%
9	" " " . . .	F.	—	—	1, or 11.1%	2, or 22.2%	—	—	6, or 66.7%
11	Eastern and Middle States Indians	M.	—	—	—	—	—	—	11, or 100%
4	" " " " "	F.	—	—	1, or 25%	—	1, or 25%	—	2, or 50%
1	" " " " "	Children	—	—	—	—	—	—	1
	Southwest:								
40	Southern Utah Cliff Dwellers .	M.	—	—	1, or 2.5%	—	6, or 15%	10, or 25%	23, or 57.5%
7	" " " " .	F.	—	—	—	1, or 14.3%	—	—	6, or 85.7%
7	" " " " .	Children	—	—	—	—	—	4, or 57.1%	3, or 42.9%
17	Pueblos	M.	—	—	—	—	1, or 5.9%	3, or 17.6%	13, or 76.5%
4	"	F.	—	—	1	—	—	—	3, or 75%
6	"	Children	—	—	1, or 16.7%	—	—	1, or 16.7%	4, or 66.7%

	Mexico:								
15	Tarahumares	M.	—	—	—	1, or 6.7%	—	1, or 6.7%	13, or 86.7%
17	"	F.	1, or 5.9%	—	1 also post., or 5.9%	—	—	1, or 5.9%	14, or 82.4%
5	"	Children	—	—	—	—	—	1, or 20%	4, or 80%
62	Tarascos	M.	—	—	1, or 1.6%	2, or 3.2%	2, or 3.2%	3, or 4.8%	54, or 87.1%
18	"	F.	1, or 5.6%	—	—	1, or 5.6%	—	4, or 22.2%	12, or 66.7%
4	"	Children	—	—	—	—	—	3, or 75.0%	1, or 25%
63	Various parts of Mexico	M.	—	—	—	1, or 1.6%	4, or 6.3%	7, or 11.1%	51, or 80.9%
29	" " " "	F.	1, or 3.4%	—	—	1, or 3.4%	2, or 6.9%	5, or 17.2%	20, or 69%
4	" " " "	Children	—	—	—	1, or 25%	—	1, or 25%	2, or 50%
70	Peruvians (1st Series)	M.	—	—	—	2, or 2.9%	7, or 10%	16, or 22.9%	45, or 64.3%
30	" " "	F.	—	—	—	4, or 13.3%	—	8, or 26.6%	18, or 60%
82	Peruvians (2d Series)	M.	1, or 1.2%	—	1, or 1.2%	4, or 4.9%	6, or 7.3%	14, or 17.1%	55, or 67.1%
20	" " "	F.	—	—	—	—	3, or 15%	3, or 15%	14, or 70%
12	" " "	Children	—	—	—	—	1, or 8.3%	3, or 25%	8, or 66.7%
92	Peruvians (3d Series)	M.	—	—	1, or 1.1%	3, or 3.2%	6, or 63%	15, or 16.3%	67, or 72.8%
8	" " "	F.	—	—	—	1, or 12.5%	1, or 12.5%	1, or 12.5%	5, or 62.5%

Totals of American Aborigines.	Anterior Incisures.			Posterior Incisures.			No Incisures.
	Right only.	*Left only.*	*On Both Sides.*	*Right only.*	*Left only.*	*On Both Sides.*	
473 Males	1, or 0.2%	—	4, or 0.8%	13, or 2.7%	32, or 6.8%	73, or 15.4%	350, or 74%
148 Females	3, or 2%	—	4, or 2.7%	10, or 6.8%	7, or 4.7%	23, or 15.5%	101, or 68.2%
41 Children	—	—	1, or 2.4%	1, or 2.4%	1, or 2.4%	13, or 31.7%	25, or 61%

been described. I have met with it in the skulls of whites as well as in those of Indians. It is a rare condition, much more rare in the Indians than the divisions in the posterior portion of the malar. Thus far I have found no specimen which would offer an explanation of the significance of this superior incisure. Occasionally, as in the specimen illustrated in the accompanying figure, it is in a curving line with several malar foramina.

FIG. 11.

In my examination for malar divisions I came across three specimens which may prove of interest in connection with this paper.

In looking over the few bear skulls in the collection in the College of Physicians and Surgeons (New York), I found one with a peculiar anomaly present on both sides. Both malar bones in this specimen show a partial separation of the frontal process, but no other division. There is, however, on each side a complete separation, by a previous, well-serrated suture, of that portion of the zygomatic process of the temporal bone which covers the temporal process of the malar (Fig. 12).

The two other specimens are human malars (Nos. 1068 and 1069, College of Physicians and Surgeons, New York), one of which shows the marks of a complete, the other those of an incomplete, vertical fracture. Both of these malars present a pronounced depression over their temporal portion.

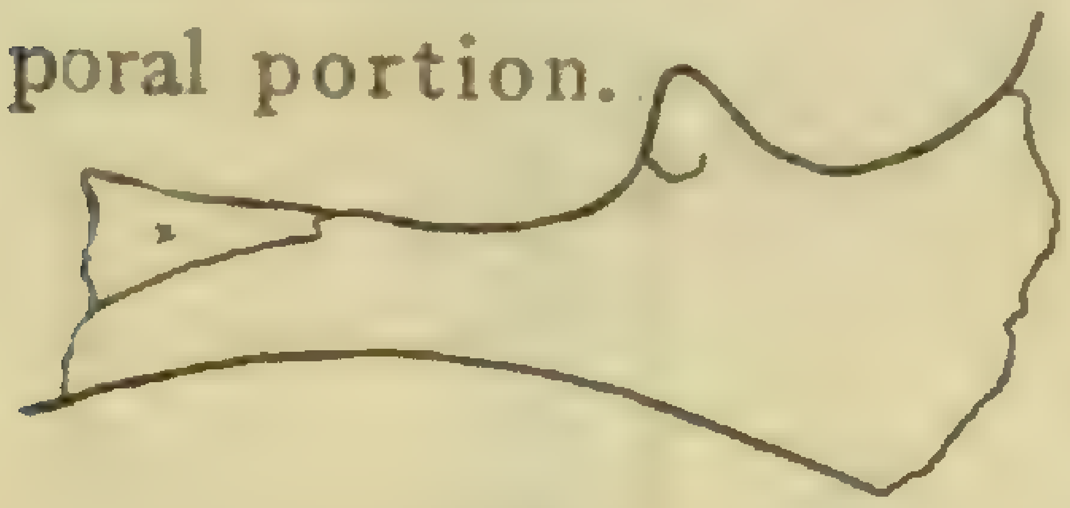


FIG. 12.

FIG. 13.

FIG. 14.

Some force was undoubtedly applied to this point, and the malar bone was fractured over and along the line of the internal malo-maxillary articulation. The border of the maxillary articular surface acted as a fulcrum over which the bone broke. There is no callus formation, and both cases bear some resemblance to a malar suture (Figs. 13 and 14).

In connection with the search for malar incisures in Indians two other points were noted, namely, the lineal, antero-posterior groove on the ventral surface of the malar (Gruber) and the temporo-maxillary arc. The groove was found to be almost constant, while the arc is generally more or less incomplete.

NOTE.

While my paper on malar divisions has been in the hands of the printer, the American Museum of Natural History has received two skulls of adult African lions, one of which shows a partial malar suture.

The suture is in the left malar; the right malar has been fractured (post-mortem), and its posterior half is wanting. Dorsally, the separation runs sagittally from a point slightly posterior to the angle of the temporal border of the malar and a somewhat greater distance anterior to the zygomatic suture, over more than half of the malar, after which it bends downward and terminates; the division is somewhat serrated and contains five small Wormian ossicles. Ventrally, the malar suture runs in a serrated manner a short distance forward and unites with the boundary of a large Wormian bone, the anterior extremity of which reaches to a point slightly posterior to the dorsal termination of the suture.

FIG. 15.

The malar shows no signs of any recent or old injury, and the division is undoubtedly congenital. It is probably a remnant of a complete malar suture, the anterior extremity of which became subject to an early synostosis. The curving anterior end can be explained by a simultaneous excess in growth of the anterior portion of the superior, and the posterior portion of the inferior, part of the malar.

The frontal process of the bone shows in its summit a vertical incisure.

There are eighteen other lion skulls of various ages in the Museum, but in none of these is there any indication of a sagittal malar division.

COLLATERAL BUDDING IN ANNELIDS OF THE GENUS TRYPANOSYLLIS.

HERBERT PARLIN JOHNSON.

ASIDE from the marvelous development of an extensively branching stock in *Syllis ramosa*, the only mode of asexual proliferation hitherto known among annelids is the linear stolonization so well exemplified by species of Autolytus, Myrianida, Procerastea, Nais, and a few other genera of small chætopods. Previous to the discovery of the extraordinary forms about to be described, the production of numerous *collateral* buds from a definite and circumscribed proliferating region has never, it is safe to say, been even imagined as among the possibilities of annelid development.

As briefly announced more than a year ago,[1] two species of Syllidæ living on our Pacific coast have been found to produce sexual zooids by collateral budding. These I have studied as fully as the scanty material permits, and the results, though far from complete, are, I trust, of sufficient interest to warrant their publication, particularly as the obtaining of more material is a matter of great uncertainty.

Both species undoubtedly belong to the genus Trypanosyllis as defined by Malaquin,[2] and both are unusually large for syllidians. The larger, for which the name *Trypanosyllis ingens* is proposed, is a veritable giant of its kind, measuring 13 cm. in length, exclusive of the tail buds, and 6 mm. in width. The only specimen of this rare species I have seen was given to me by Prof. Harold Heath of Stanford University, to whom my grateful acknowledgments are due. It was found by him under a stone between tide marks, at Pacific Grove, California.

[1] Johnson, H. P. A New Type of Budding in Annelids. Paper read at the eleventh annual meeting of the American Morphological Society at Baltimore, Dec. 27, 1900. An abstract was published in the *Biological Bulletin*, vol. ii, No. 6 (1901). [2] Malaquin, A. *Recherches sur les Syllidiens*, p. 72. Lille, 1893.

The worm is much flattened in the horizontal plane, measuring only 2 mm. in its greatest dorso-ventral diameter. The parapodia (Fig. 1) are very diminutive for the size of the trunk, and the somites are so short that the stout dorsal cirri (inasmuch as their thickness exceeds the length of the somites) form an alternating series. The somites number nearly 500.

As *Trypanosyllis ingens* is undoubtedly new to science, a diagnostic description, with figures sufficient for its identification, is given. It is unfortunately too rare to serve as a

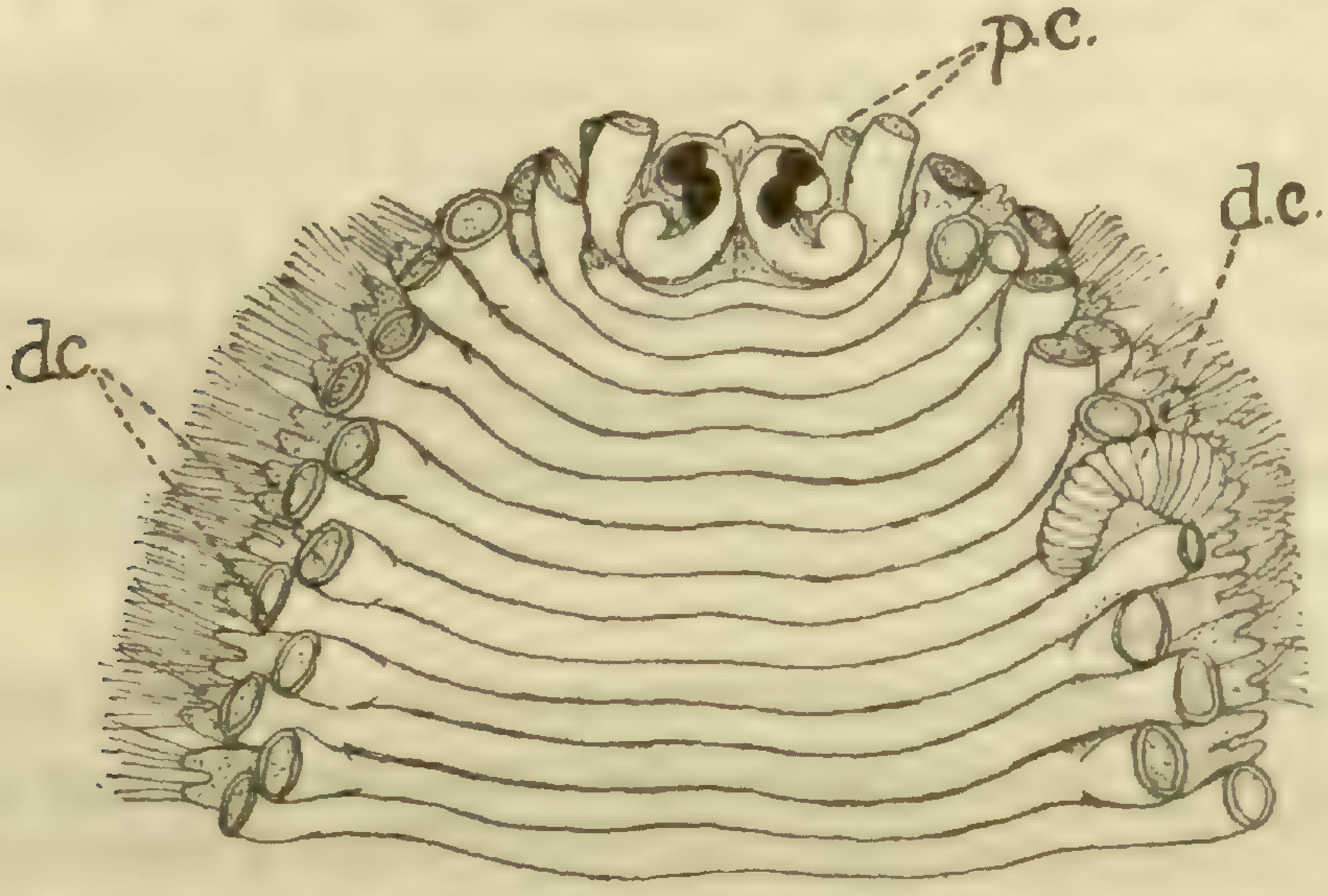


FIG. 1. — Anterior extremity of *Trypanosyllis ingens*. The palpi, antennæ, median cirrus, peristomial cirri, and all the dorsal cirri, with one exception, are broken off at the basal constriction. *p.c.*, peristomial cirri; *d.c.*, dorsal cirri. × 12.

subject for study of collateral budding. It occurs in none of the numerous gatherings of Pacific coast Polychæta that came into my hands during six years' residence in California; and Dr. Heath, who has done a great deal of collecting at Pacific Grove and vicinity at all seasons of the year, informs me that he has found only this specimen.

Trypanosyllis ingens sp. nov.

Form elongated, broad, much depressed; dorso-ventral differentiation very slight, dorsum slightly convex, ventral surface plane, longitudinally bisected by a narrow median welt, sharply bounded by two fine parallel grooves; extremities evenly and abruptly rounded off; slightly more tapered posteriorly than anteriorly; somites very short, crowded, about 476 in number.

General coloration tawny; parapodia, dorsal cirri, and anterior extremity, purple; caudal buds, from presence of ova, rich yellow.

Prostomium (Fig. 1) trapezoidal, its length two-thirds of its width, distinctly bilobed, the lobes scroll-shaped, with a deep median notch at posterior border; eyes 4, on anterior scrolls, connate. Palpi, antennæ, and median cirrus, all wanting in the type specimen.

Peristomium somewhat broader than the prostomium, enclosing the latter posteriorly and on the sides; with dorsal and ventral peristomial cirri (Fig. 1, *p.c.*).

Parapodia uniramous, short, crowded, with bases of the dorsal cirri interlocking (Fig. 1, *d.c.*); dorsal cirri (Fig. 2, *d.c.*) thick, coiled, articulated, rather rapidly tapering towards the tip; ventral cirrus tongue-shaped or fusiform; setæ (Fig. 3) 11–13 in each foot, with

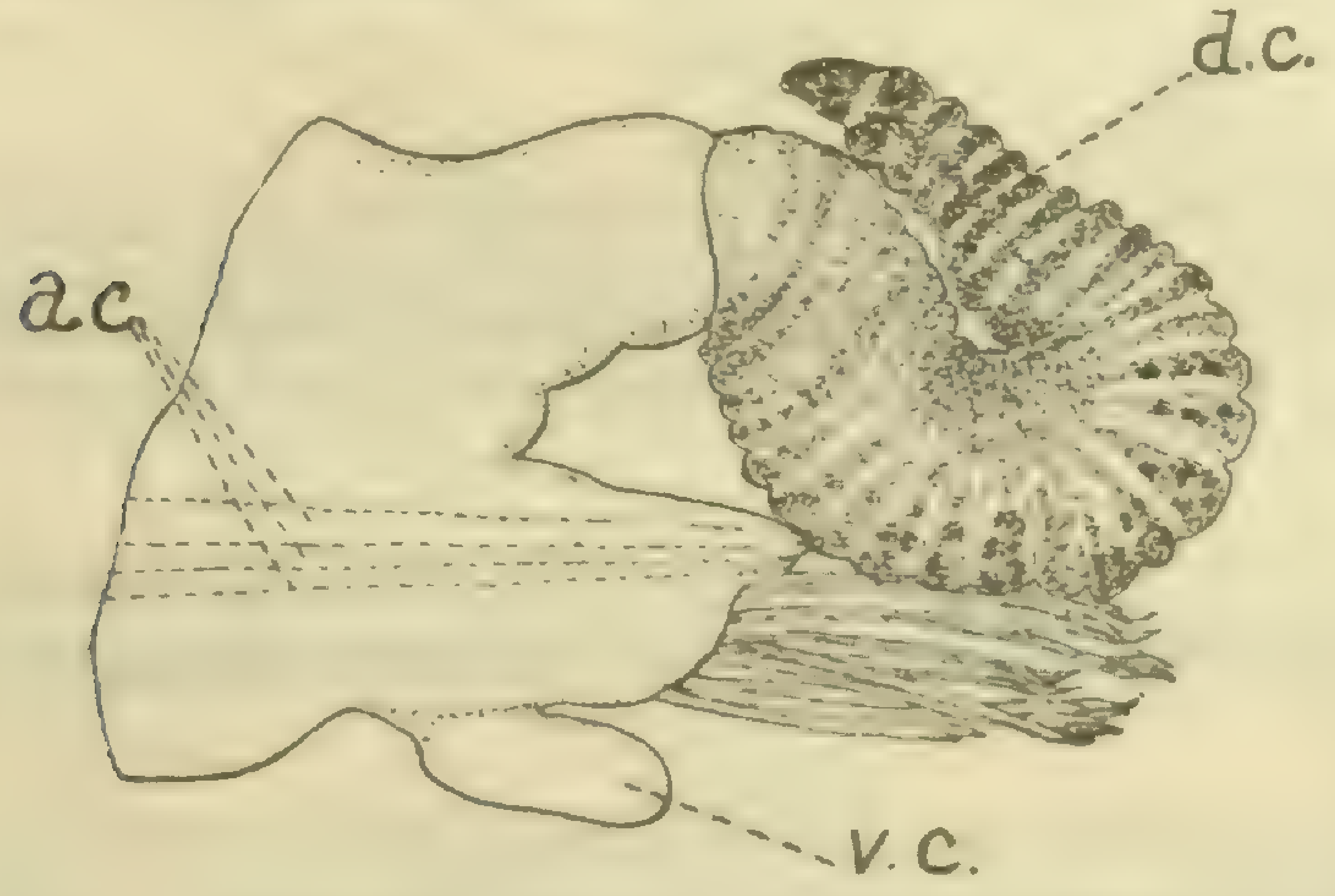


Fig. 2.

Fig. 3.

Fig. 4.

Fig. 2. — Foot of *Trypanosyllis ingens*, from about the middle of the length. *ac.*, aciculæ (three); *d.c.*, dorsal cirrus; *v.c.*, ventral cirrus. × 30.

Fig. 3. — Seta of the same, in profile. × 467. Fig. 4. — Seta, sexual zooid of the same. × 467.

toothless hooked appendage; aciculæ (Fig. 2, *ac.*) 3–5, their distal ends extending into two finger-like lobes, one usually much thicker than the other, at the dorsal tip of the foot.

Mouth large, its transverse diameter equal to width of prostomium; bounded by 7 crenulations. Somites 1–8 curved backward around mouth, as in Amphinomidæ and Palmyridæ.

Proboscis short and small (2 mm. long), thin-walled, bounded posteriorly by a double ring of fleshy papillæ, 9–10 in each ring, those of the outer circle more than twice as long as the inner ones.

Œsophagus short (3.5 mm.), and of small diameter (1 mm.) for the size of the animal, with usual chitinized lining, which terminates in a "trephine" anteriorly. Œsophagus surrounded

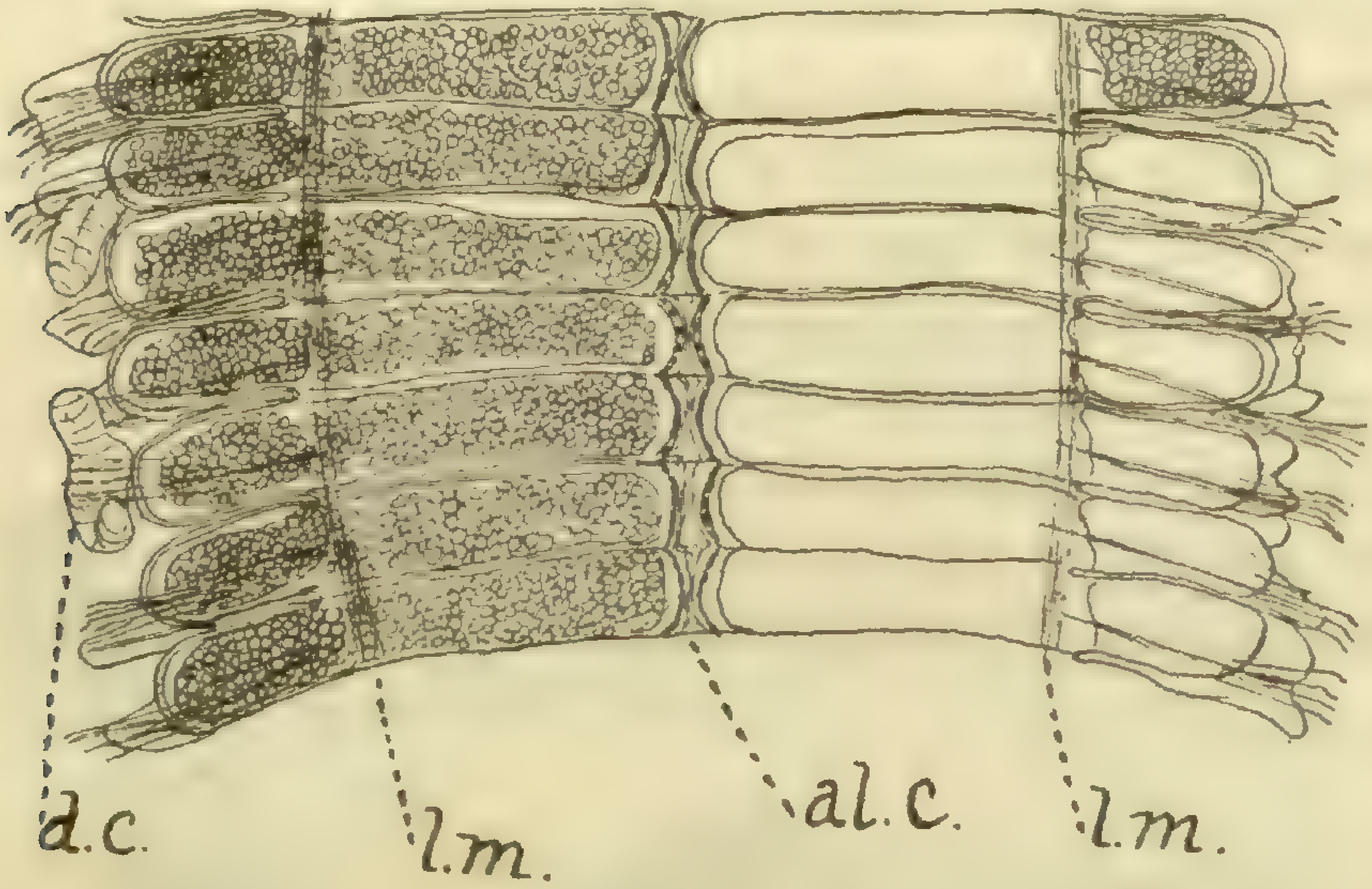


FIG. 5.—Seven somites from the middle region of a female sexual zooid of *Trypanosyllis ingens*, viewed from the dorsal aspect. With two exceptions (*d.c.*) the dorsal cirri are broken off. The rudimentary alimentary canal (*al.c.*) is indicated; also the ova on the left side and in one parapod on the right. The longitudinal muscle bands (*l.m.*) mark the bases of the parapodia. In clove oil. × 19.

by 9–10 glands, of wavy or crenulate outline, opening near the papillæ, their blind ends extending back a short distance on the proventriculus.

Proventriculus also small for size of the animal, 6 mm. long, 1.5 mm. in greatest transverse diameter, slightly club shaped, thickest anteriorly, tapering gradually to posterior end; two well-defined raphes. No cœca were detected.

Intestine with extensive paired diverticula in every somite back of the proventriculus.

Sexes distinct; sexual products, so far as known, developed only in a cluster of collateral buds, growing from a definite proliferating region near the posterior end; probably also in the parental somites posterior to the budding zone.

Length, 130 mm.; greatest transverse diameter, including parapodia, 6 mm.; dorso-ventral diameter, 2 mm.

Habitat, Pacific Grove, California; between tide marks.

The form seemingly most nearly allied to *T. ingens* is *Trypanosyllis gigantea* (M'Intosh) Ehlers of the Southern Ocean. The latter is but little inferior in size, measuring, according to M'Intosh,[1] 90 mm. in length and 7 mm. in breadth. The form

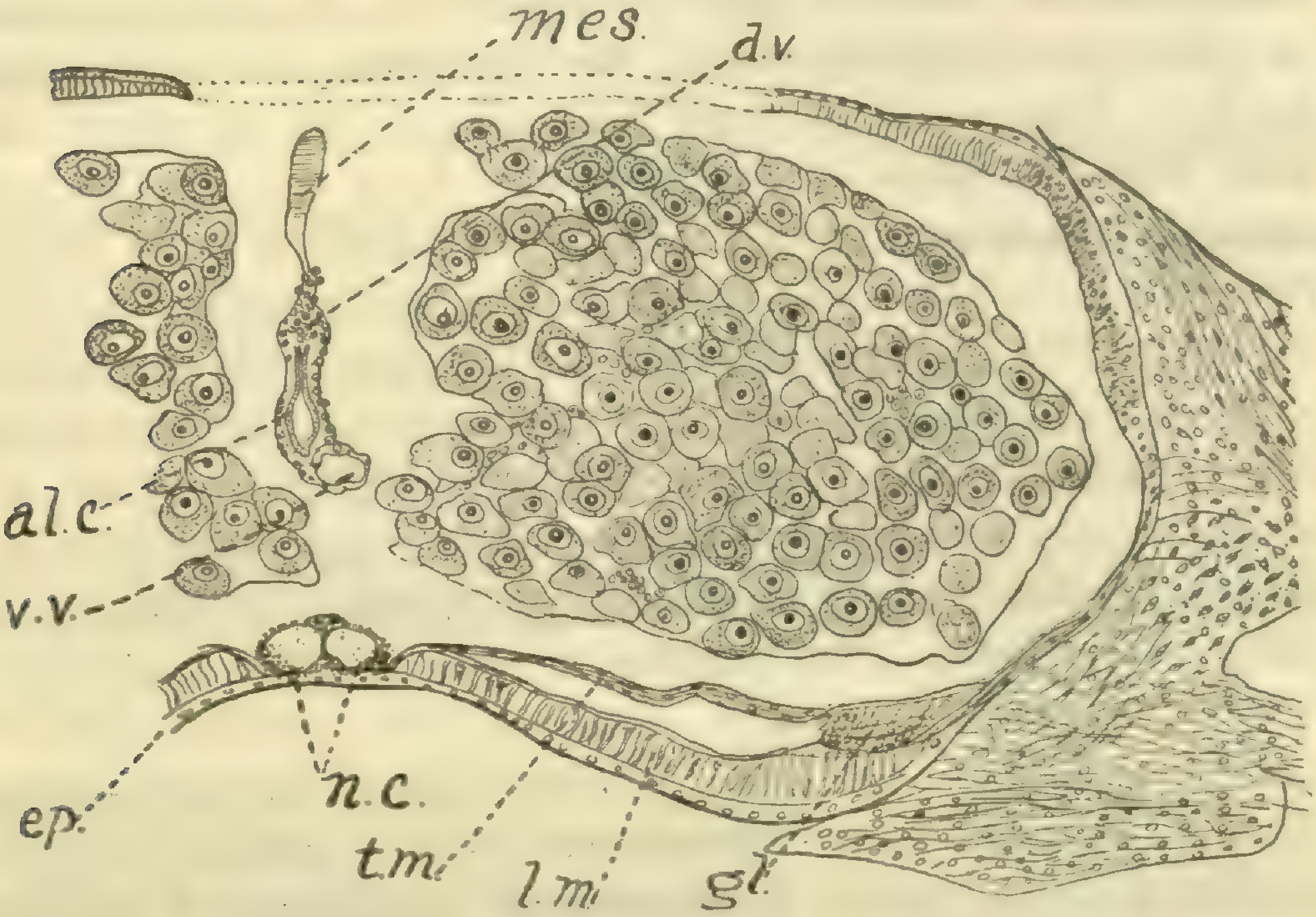


Fig. 6. — Transverse section, female zooid of *T. ingens*, right half. A portion of the dorsal body wall (indicated by dotted lines) is broken away. The plane of the section encounters the septum on the right. *al.c.*, rudimentary alimentary canal; *d.v.*, dorsal blood vessel; *v.v.*, ventral ditto; *mes.*, dorsal mesentery; *gl.*, problematic glandular structure (external extremity); *n.c.*, nerve cords; *l.m.*, longitudinal musculature; *t.m.*, transverse muscle; *ep.*, epidermis. × 100.

Fig. 6 *A*. — Problematic gland-like tube, from right side of another section of the same series, with portion of body wall adjacent. The external extremity (aperture?) is toward the right. The tube is laid open by the section, showing ends of columnar cells. Lettering as in Fig. 6. × 100.

is very similar, the parapodia of both have multiple aciculæ (6 in *T. gigantea*), and the setæ of the two species are practically identical. There is nothing, however, in M'Intosh's description or in his figure of a cross-section to indicate that

[1] M'Intosh, W. C. Challenger Reports. *The Polychæta*, vol. xii (1887), p. 193.

T. gigantea has the great intestinal diverticula so conspicuous in *T. ingens* and in *T. gemmipara* (Fig. 16). The prostomium of *T. gigantea* is also of simpler form.

Unfortunately the delicate tail buds of this formalin-preserved specimen were somewhat macerated and broken in transportation ; most of them had fallen off, and probably some of them were missing, when the specimen came into my hands. They number about 30, and are all at about the same advanced stage of development. Each bud exhibits the external characters of the stock. Its somites have nearly the same proportions ; its parapodia, with their diminutive cirri and setæ (Fig. 5), are of the same pattern, with the slight difference that the appendages of the setæ have a small tooth and minute serrations on the concave side, while these are absent in the setæ of the stock (*cf.* Figs. 3, 4). The average length of the buds is 5 mm., their breadth 2 mm., their thickness 0.5 mm. The number of their somites is approximately 25.

Each zooid is divided into a double series of cœlomic spaces by the intersegmental dissepiments and a minute median tubular structure, which I interpret as a rudiment of the alimentary canal (Figs. 5, 6, *al.c.*). The cœlomic spaces, including even the parapodial cavities (Fig. 5), are packed full of eggs, which possess very large nuclei and nucleoli, the latter usually vacuolated (Fig. 6). No ova have been found in the parent stock. The longitudinal muscular system of the bud is not highly developed (Figs. 5, 6, *l.m.*), and no circular musculature was detected. Circular muscles are very slightly developed in the stock. There is a slender transverse muscle extending from the lateral body wall to the nerve cord (Fig. 6, *t.m.*). This, however, I suspect is not so much a separate muscle as a portion of the very extensive system of septal muscles.

A dorsal and a ventral blood vessel (Fig. 6, *d.v.*, *v.v.*) are seen close to the digestive tract. The ventral vessel with its coagulum is apparently of uniform diameter throughout its course, while the dorsal vessel is segmentally constricted (Fig. 6 represents a constricted place). No lateral branches have been detected.

A pair of problematic organs, possibly much-modified nephridia, are present in each segment. These organs are tubular, with rather narrow lumen, their thick walls composed of columnar, much-vacuolated cells (Fig. 6 *A*), and no opening has been seen at either extremity. They occupy a ventral position, the internal extremity being directed towards the median line, and the outer extremity obliquely towards the

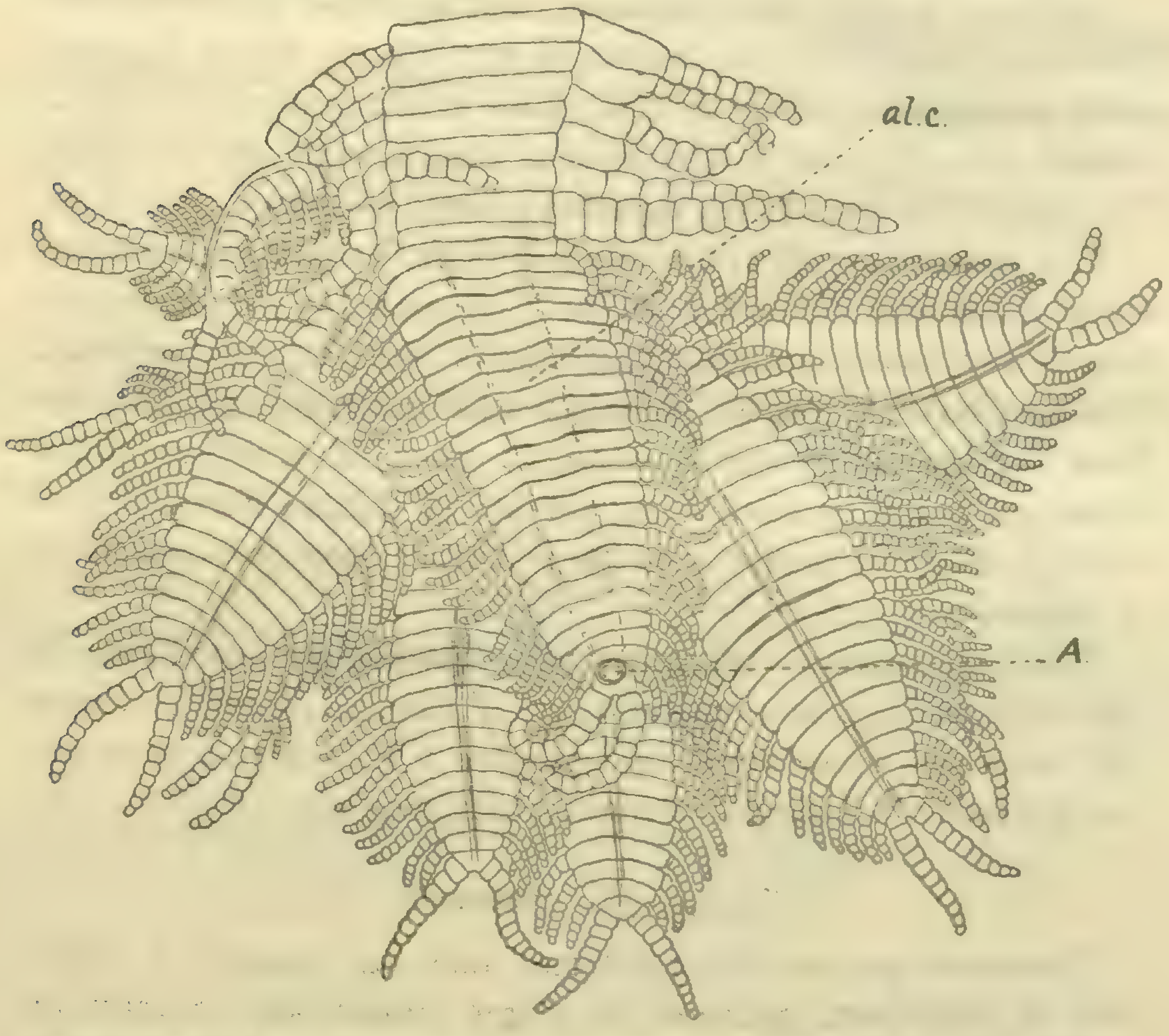


Fig. 7.—Caudal buds of *Trypanosyllis gemmipara*, dorsal aspect. The posterior ciliated portion of the intestine (*al.c.*) and the anus (*A*) are shown in the attenuated caudal portion of the stock. × 26.

ventral body wall, which it penetrates as far as the epidermis. It is known that in several species of syllidians the segmental organs serve as genital ducts, and for this purpose undergo enlargement at sexual maturity.[1] Such a function would seem to be impossible in this instance when we compare the diameter of the ova with the diameter of the tubes.

[1] Ehlers, Ernst. *Die Borstenwürmer* (1864), p. 215.

A pair of ventral nerve cords (Fig. 6, *n.c.*) are conspicuous in transverse sections, in which the cut ends of the nerve fibers appear, surrounded at intervals by a few darkly stained bodies, the nuclei of ganglionic cells. The ganglia, one to each segment, can be plainly seen in a zooid cleared with glycerine. The nerve cords, although in direct contact with the epidermis, are plainly not fused with it.

No head or eyes were detected; but as these structures are obviously present in the zooids of the closely allied *Trypanosyllis gemmipara*, failure to find them in the present species is almost certainly due to the broken condition of the material, the tips of the buds being especially liable to injury.

The place of origin of the buds is near the posterior extremity of the stock. Probably, as in *T. gemmipara*, it is about the length of a zooid, or twenty somites, in front of the pygidium. The proliferating region, although now destitute of buds, has been sectioned, and shows merely a mass of undifferentiated tissue pervaded by a radiating system of muscle fibers, which, in all probability, passed into the zooids, as they certainly do in *T. gemmipara*.

The rudimentary and apparently functionless condition of the alimentary canal is noteworthy. Although impossible, from the defective material, to tell whether a mouth and anus are really absent, it is highly probable that they are.

Trypanosyllis gemmipara.

The other species with collateral buds was found in a collection of Polychæta gathered in Puget Sound and vicinity by Nathan R. Harrington, since deceased, member of the expedition sent out by Columbia University in the summer of 1896. It has been described and figured in the writer's report[1] on the Polychæta of that expedition under the name *Trypanosyllis gemmipara*.

Although much smaller than the preceding, *T. gemmipara* is nevertheless very large for a syllid. The Puget Sound specimen measures 68 mm. in length and 3 mm. in width. Like

[1] Johnson, H. P. The Polychæta of the Puget Sound Region, *Proc. Boston Soc. Nat. Hist.*, vol. xxix (1901), No. 18, p. 405, Figs. 72–76.

T. ingens, and in fact most, if not all, species of this genus, *T. gemmipara* is much flattened horizontally, being only 1 mm. in dorso-ventral diameter. The somites number about 300, and, as in *T. ingens*, their width many times exceeds their length.

The tail buds, 50 in number, present all stages of development. They form a tuft arising from the ventral aspect near the posterior extremity, and superficially resemble a bunch of

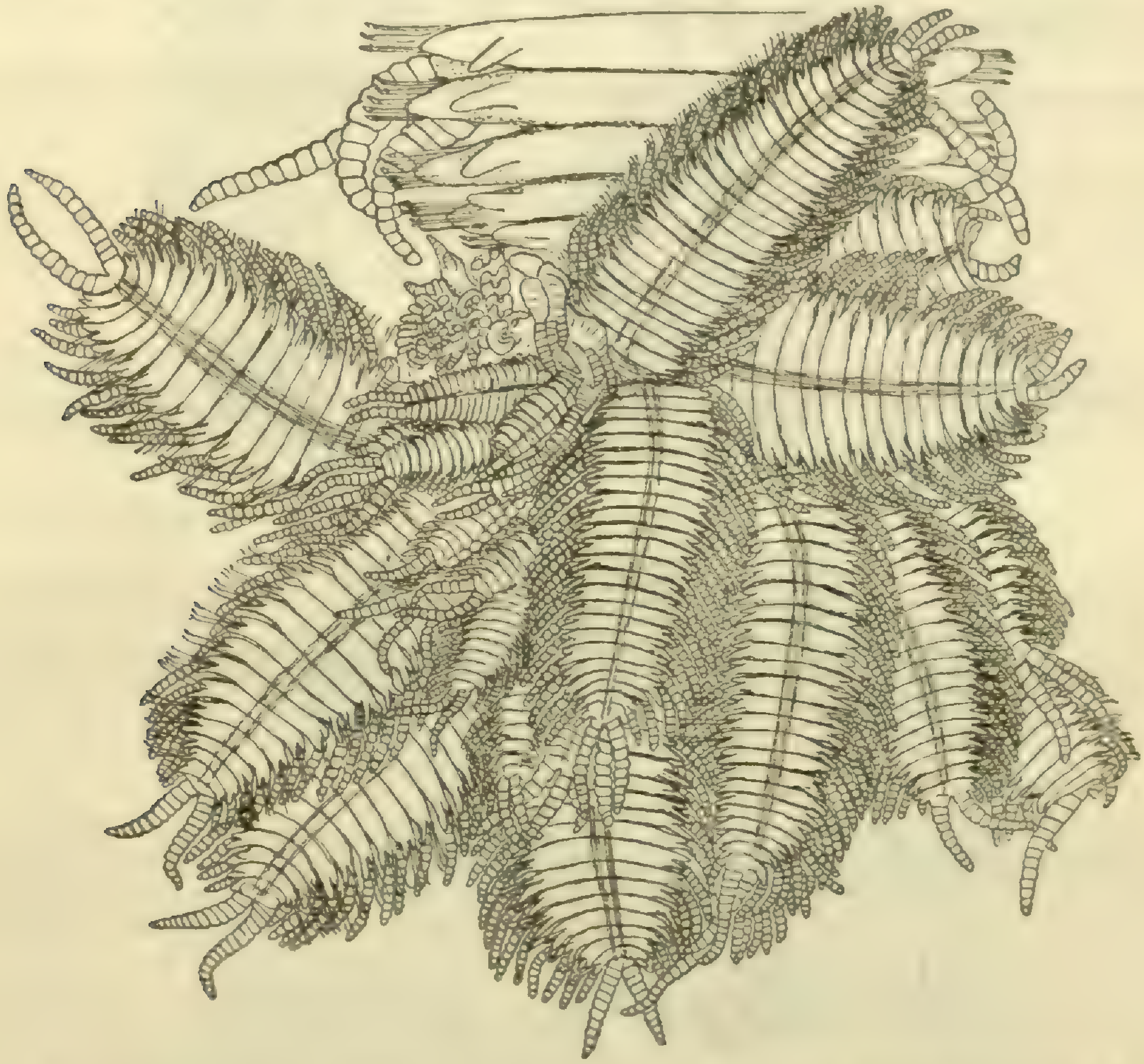


FIG. 8.—Caudal buds, ventral aspect, of *T. gemmipara*. The young buds are seen on the left of the figure. × 26.

ferns (Figs. 7, 8). Neither as regards position nor order of development do they obey the laws of bilateral symmetry. The whole cluster is bent to the right, making an angle of about 25° with the longitudinal axis of the worm. Only 13 of the buds have reached an advanced stage of development; these are elliptical in shape, rather thin in proportion to their other dimensions, and possess the chief external characters of

the parent. Their somites are 20 to 28 in number; their small but well-developed parapodia are furnished with moniliform dorsal cirri and minute setæ of the same form as those of the parent. The average length of a mature bud is 2.5 mm.;

FIG. 9. — Frontal section through budding zone of *T. gemmipara*, showing male zooids at different stages (b–b^6) of development. The zooids are cut at various planes (the two in the center of the figure, marked b^5, nearly in the median sagittal plane). The youngest buds are marked b; b^1 indicates a bud in which segmentation is just beginning; b^2, b^3, buds in which segmentation is completed except at distal end, and the parapodia are already well developed; b^4–b^6, buds progressively older; *br.*, brain; *d.c.*[1], first dorsal cirrus; *l.m.*, longitudinal muscles; *n.c.*, nerve cord; *sp.*, sperm cells. × 50.

the breadth, including parapodia, is 1 mm. The bud tapers more towards the caudal than towards the cephalic extremity. The anal cirri are longer and thicker than any of the dorsal cirri (Figs. 7, 8).

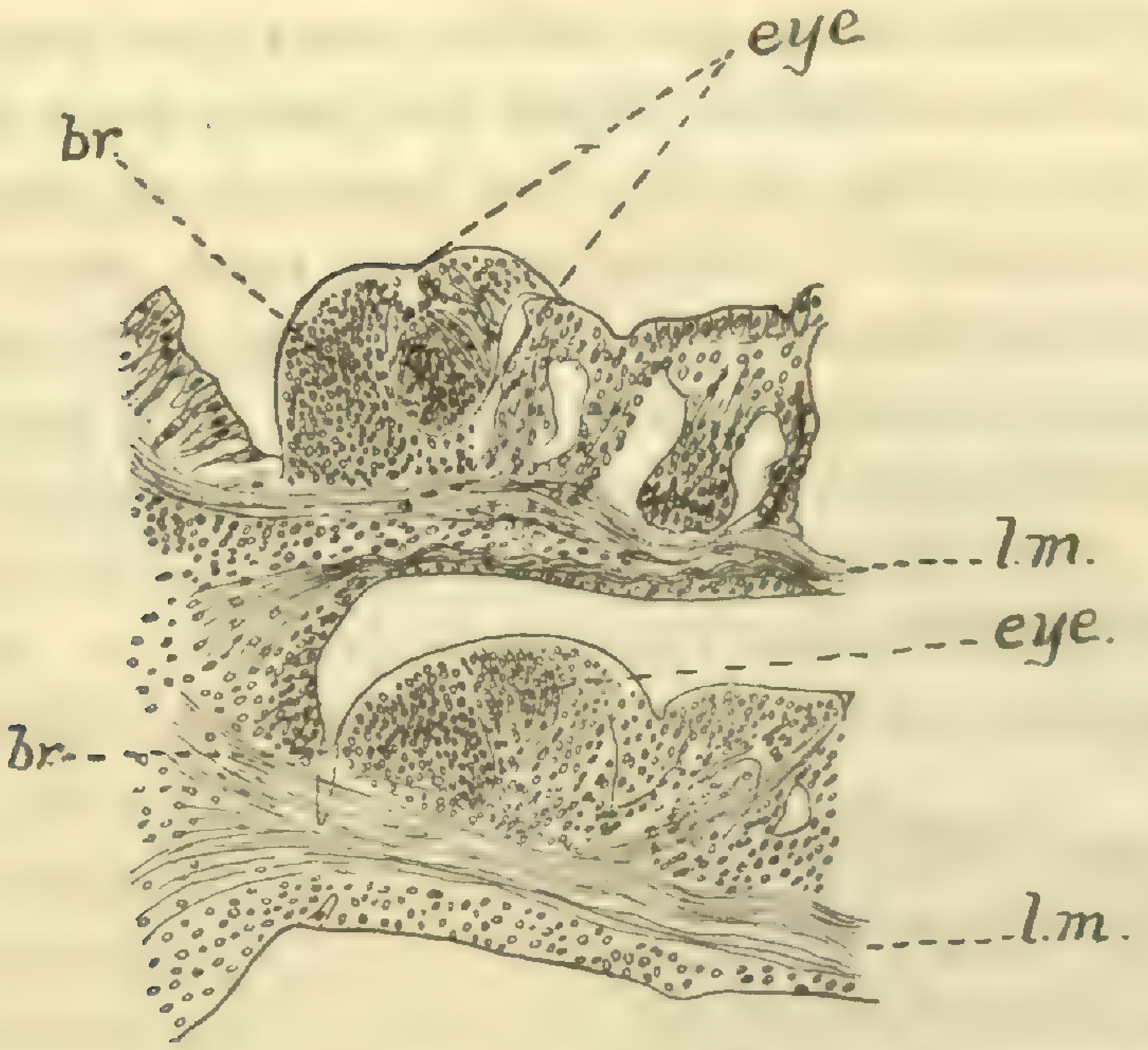


FIG. 9 *A*. — Anterior extremities of zooids marked b^5 in Fig. 9, showing, at two different stages, the *Anlagen* of eye and brain as they appear in a section further from the median plane of the zooids than that represented in Fig. 9. The extension of the ventral longitudinal muscles of the zooids into the proliferating zone of the stock is clearly indicated. Lettering as in Fig. 9. × 200.

FIG. 9 *B*. — Transverse section of group of young buds, taken in same direction (frontal), but at lower level than Fig. 9. The arrangement in transverse rows is clearly indicated. Buds at extreme left are cut obliquely; in one of these (b^1), segmentation of the mesoderm is beginning. *ec.*, ectoderm; *mes.*, mesoderm. (Semidiagrammatic.) × 147.

Only advanced buds are visible from the dorsal aspect (Fig. 7). These completely cover the young buds on the ventral side and overlap so that the heads of all the advanced buds are concealed. Occupying the most dorsal position amongst the advanced buds is the attenuated and rapidly diminishing caudal extremity of the stock. It is much like the buds in general aspect, and further resembles them in containing sperm cells, which are absent in all portions of the stock in front of the proliferating region. It differs from the buds in possessing (1) a heavily ciliated continuation of the alimentary canal (Fig. 7, *al.c.*), (2) the anus, and (3) differs in lacking cephalization. In every respect except that it contains sperm cells, it resembles a regenerated posterior extremity. It possesses twenty-four somites, including the pygidium. The proliferating region is therefore this number of somites in front of the posterior extremity. As Fig. 7 shows, the attenuated posterior portion has almost as much the appearance of being an appendage to the budding zone as any of the mature buds.[1]

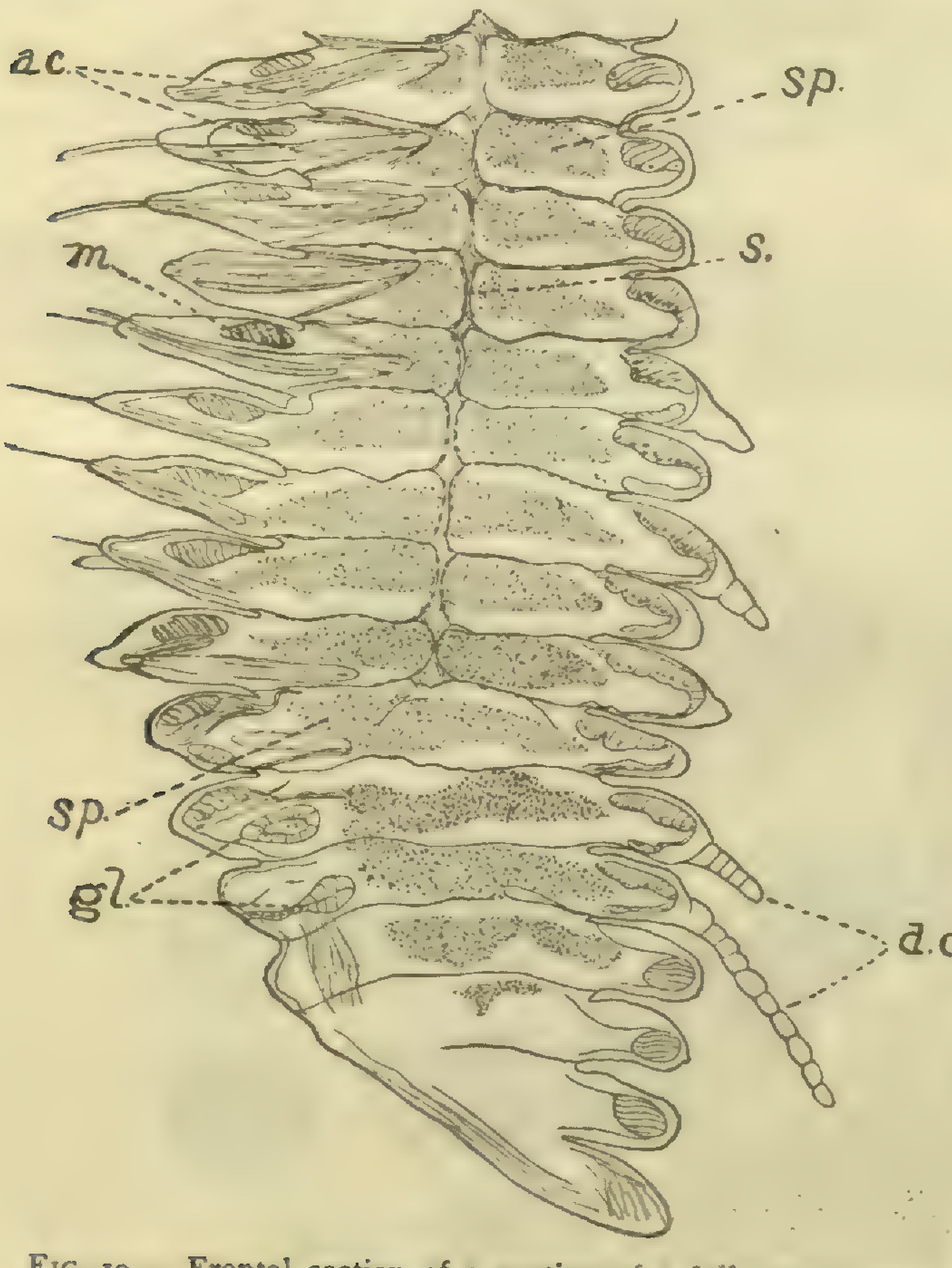


FIG. 10. — Frontal section of a portion of a full-grown bud of *T. gemmipara*, showing sperm masses (*sp.*), parapodia, dorsal cirri (*d.c.*), setæ, aciculæ (*ac.*), muscles (*m.*), and parapodial glands (*gl.*). The intersegmental dissepiments and median strand (*s.*) are indicated. × 75.

It is worthy of note that into this region the deep intestinal

[1] This attenuated posterior extremity is probably a permanent feature. I have found it in every entire specimen of *T. gemmipara* I have collected on the California coast, but the number collected is small.

diverticula do not continue. The diverticula of this portion of the alimentary canal are very shallow, and were not detected in the entire specimen (Fig. 7).

The attachment of the buds to the proliferating area (invisible in the entire specimen) is by a short unsegmented pedicle at the cephalic extremity of each bud (Figs. 9, 9 *A*, 17, *p.*). There is no distinct prostomium. The head is merely the eye- and brain-bearing first segment, which shows its primitive character by also carrying parapodia equipped with dorsal cirrus, setæ, and aciculæ (Fig. 9, *d.c.'*). This fact is significant, because it is exactly what we find in the stolons of not a few syllidians, among others those of *Trypanosyllis krohni.*[1]

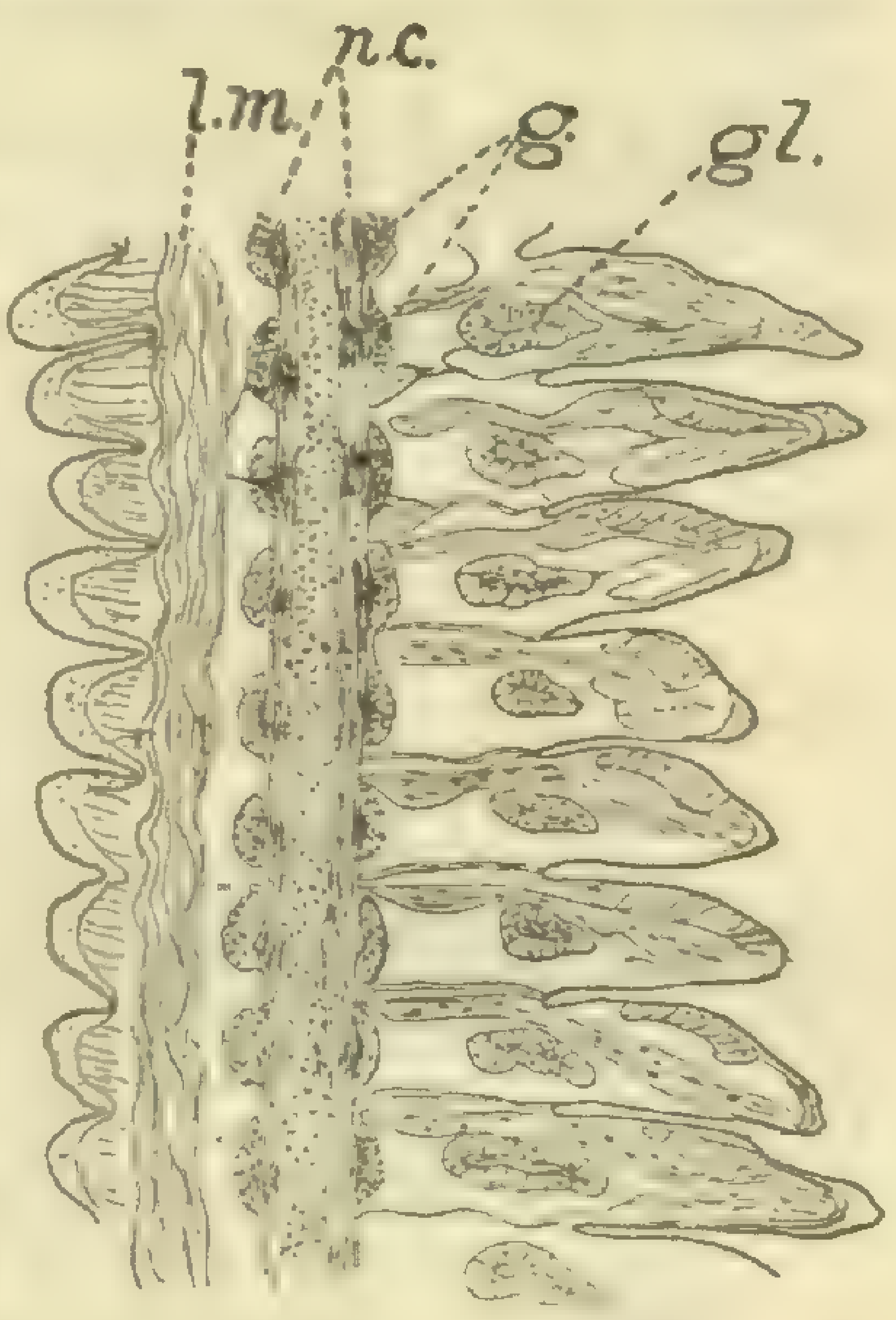


Fig. 11.— Frontal section at a lower level, showing paired nerve cords (*n.c.*), ganglia (*g.*), ventral longitudinal muscle (*l.m.*), and parapodial glands (*gl.*). × 75.

The eyes, apparently only two (although each may represent two, completely fused), are large and highly developed, as is often the case in stolons. There is a well-defined lens (Fig. 15, *l.*), a "vitreous body" (*vt.*) composed of the rods of the retinal cells, and a very thick, cup-shaped retina, the inner layer of which contains a small quantity of brown pigment (*p.*), but not dense enough to conceal its structure.

The buds are destitute of an alimentary canal, unless the merest rudiment exists in the form of a median strand (Figs. 10, 12, *s.*). Certainly there is no tubular structure such as occurs in the bud of *T. ingens.* There is no mouth, anus, or blood vessels. The zooid is sharply divided by the dissepiments and an incomplete median partition into a double series of cœlomic spaces. That the right-and-left cœlomic chambers of the same somite are sometimes continuous is clearly shown by the sperm masses in the more posterior segments represented in Fig. 10. This seems to be the case only in the ventral portion of the chamber. The sperm masses do not

[1] See Malaquin, *op. cit.*, Pl. X, Figs. 18, 19.

completely fill the spaces, and do not seem in any case to occupy the cavities of the parapodia. Spermatozoa were not observed in any of the buds, indicating that even the oldest are not fully ripe.

The parapodia are fully equipped with dorsal and ventral cirri, setæ, a pair of aciculæ, — the latter projecting deeply into the sperm masses (Fig. 10, *ac.*), — and the usual musculature. Occupying a large portion of the cavity of each parapodium are pouch-shaped glandular structures of unknown function. Each is composed of a few very large vesicular cells, and has a good-sized lumen which appears to open near the base of the parapodium, on the ventral side (Figs. 10, 11, 13, *gl.*). No actual opening, however, has been found, and the mouth seems entirely blocked by columnar epidermal cells (Fig. 13). These glands occur in the segments of the attenuated caudal region, where they have the same size and aspect as in the buds. In the parapodia of the stock — at least those immediately in front of the budding zone — they are also found. Without much doubt these structures are homologous with the parapodial glands (*glandes pédieuses*) known to be present in *Trypanosyllis cœliaca* and in species of other genera of Syllidæ.[1] Their function is the secretion of mucus. From their histological aspect, this is probably likewise the function of the above-described glands.[2]

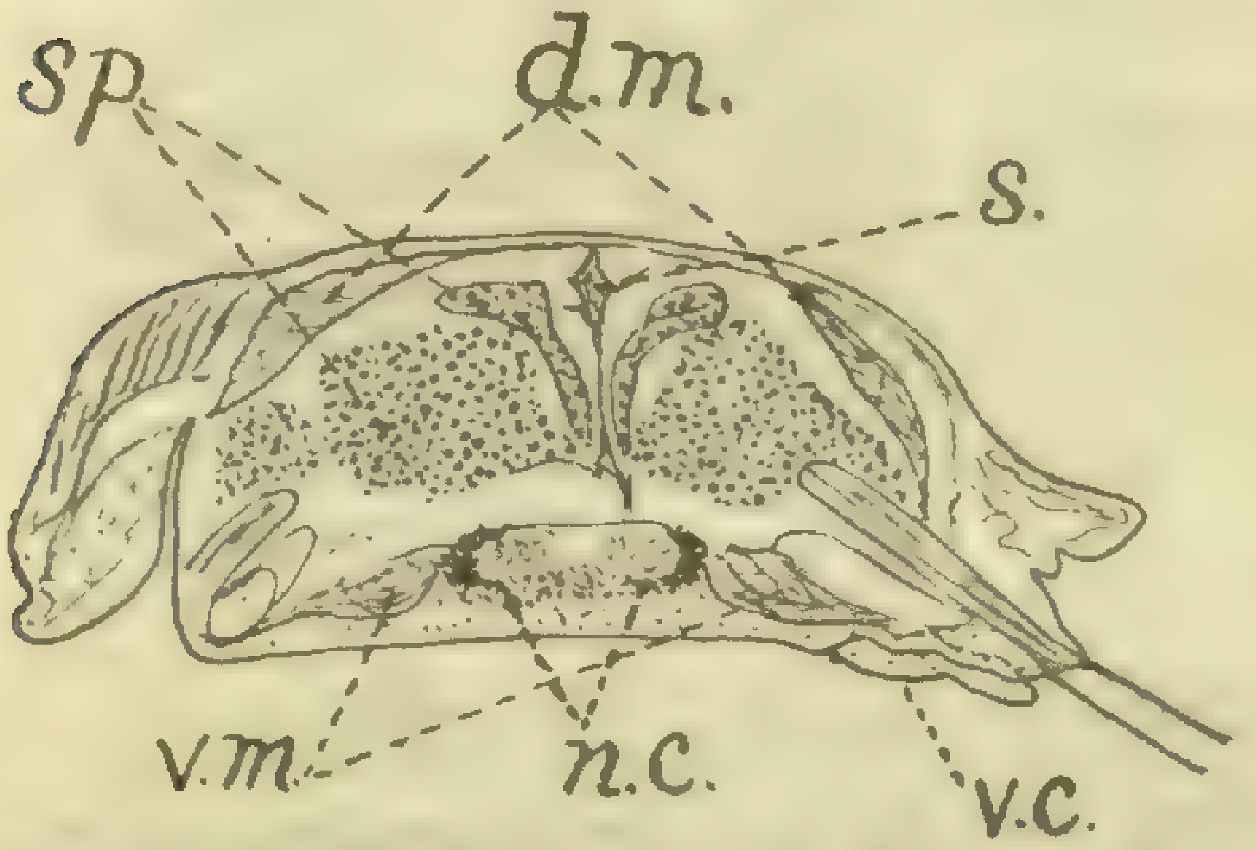


FIG. 12.— Transverse section of full-grown bud, *T. gemmipara*. *d.m.*, dorsal longitudinal muscles; *v.m.*, ventral ditto; *s.*, median strand; *v.c.*, ventral cirrus; *sp.*, masses of sperm cells; *n.c.*, ventral nerve cord, showing cut ends of fibers and ganglionic cells. × 100.

There are two large and conspicuous ventral nerve cords, with paired ganglia in every somite (Figs. 11, 12, *n.c.*, *g.*). Proportionately to the size of the bud, the nervous system is much larger in this species than in *T. ingens*. As accurately as could be made out from the single series of sections, the

[1] See Malaquin, *Recherches sur les Syllidiens*, p. 87, Pl. VII, Fig. 7.

[2] It is interesting to find that these glands are not only relatively, but absolutely, larger in the caudal segments and in the buds than in the stock.

nerve cords run forward to the cephalized extremity and there innervate the eyes and a darkly staining mass of ectodermic cells which probably functions as brain (Fig. 14, *cb.*). Although the nerve cords are plainly separate from the epidermis, as shown by a cross-section (Fig. 12, *n.c.*), the brain is no more than a thickened portion of the epidermis, and fully confluent with it. As clearly shown in one section (Fig. 14), the optic nerve comes from the ventral cord, and not from the brain.

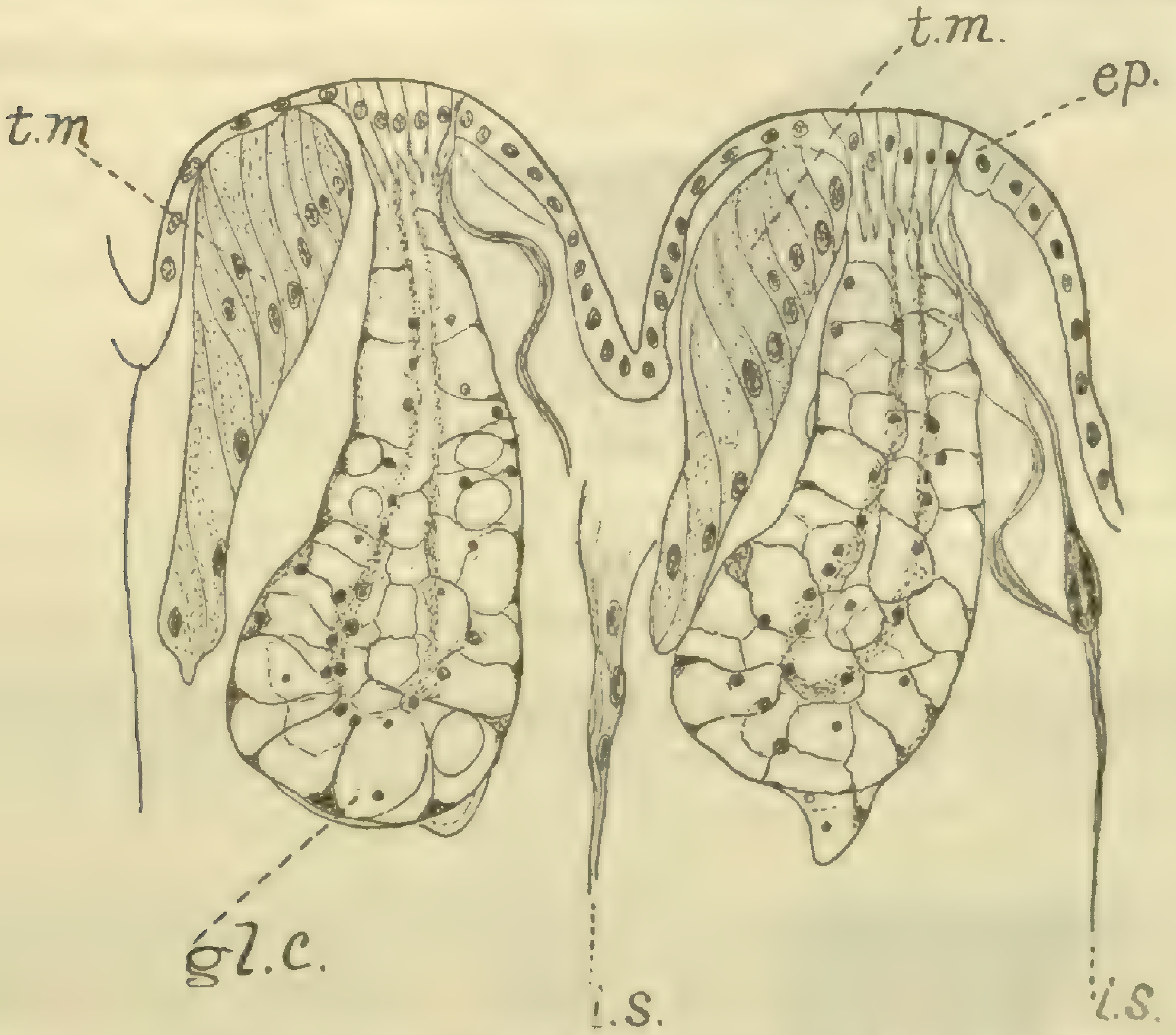


FIG. 13. — Two pedal (mucous?) glands of bud of *T. gemmipara*, in longitudinal section. The lumens of the glands are bounded by stippled bands; the gland cells (*gl.c.*) are highly vacuolated; the epidermal cells at mouth of glands are columnar. *t.m.*, transversal muscles; *i.s.*, intersegmental dissepiments; *ep.*, epidermis. × 525.

When viewed from the ventral aspect the cluster of buds presents an interesting condition of things (Fig. 8). On the right, at the base of the cluster, is a group containing about 25 very young buds (Fig. 8), as yet showing no segmentation, but each with two distal processes which are the *Anlagen* of the anal cirri. As may clearly be seen in a transverse section of the group (Fig. 9 *B*), the buds are arranged in rows, partly transverse and partly longitudinal as regards

the long axis of the stock. In a graduated series proceeding from the left side of the cluster of youngest buds are more advanced buds, the largest approaching the mature condition (Fig. 9, *b*–b^6). At an early stage the anal cirri attain a notable length and become articulated.

As shown in a frontal section (Fig. 9) through the proliferating region, the buds sprout from a mass of undifferentiated tissue traversed by muscle fibers which are continuous

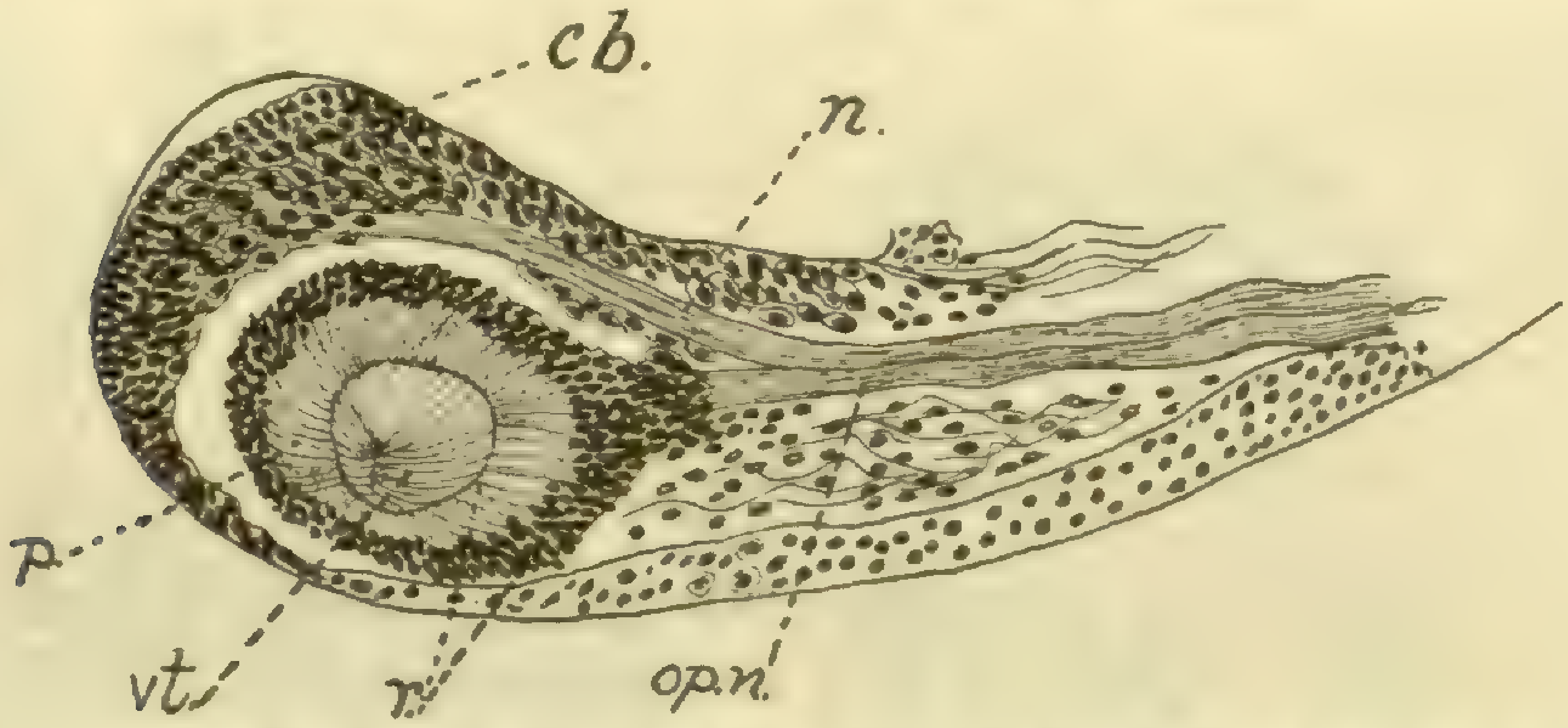


FIG. 14. — Frontal section of a portion of head, same bud as shown in Fig. 10. *n.*, nerve to brain (*cb.*); *op.n.*, optic nerve; *r.*, retina, showing rod cells and pigment (*p.*); *vt.*, "vitreous body," composed of the clear retinal rods. The nerve to the brain breaks up into numerous fibers, which are distributed to the ganglionic (?) cells. × 153.

with the longitudinal muscle bands of the buds (Fig. 9 *A*, *l.m.*). This mass is mesoderm, covered by ectoderm in the form of epidermis. Both ectoderm and mesoderm of the buds are continuous with the same germ layers of the proliferating region. Whether the proliferating mass comprises one or more than one somite cannot be positively stated from the sections at hand, which are defective at this point.

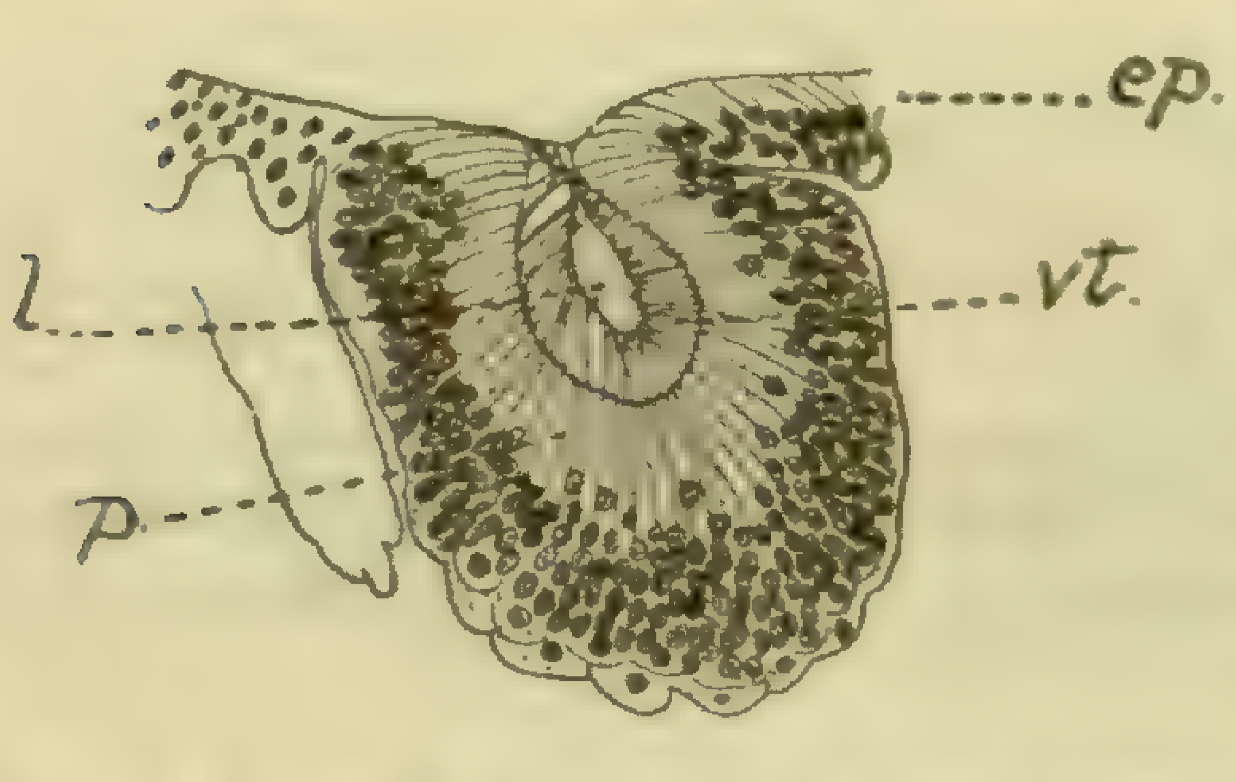


FIG. 15. — Longitudinal section of eye, showing its cup-like form, and apparent formation by an invagination of the epidermis (*ep.*). Lettering as in preceding figure; *l.*, lens. × 267.

At a very early stage the mesoderm undergoes segmentation, and the reproductive cells are discernible (Figs. 9, 9 *B*, *b*′).

No buds provided with special natatory setæ (*Pubertätsborsten*) such as usually occur in the stolons of syllids and in the sexual buds of *Syllis ramosa*[1] were observed.

[1] M'Intosh. *Challenger Reports*, vol. xii, p. 201, Pl. XXXIV A, Fig. 9.

General Considerations.

From the standpoint of comparative morphology, the collateral buds of Trypanosyllis may be regarded as structures of the same order as the stolons of Autolytus or Myrianida, but with the important difference that the buds in this case are lateral outgrowths, whereas in stolonization they are the result of linear growth and differentiation. As stolons, they extend the organic axis of the parent, and the alimentary canal passes through them all, to terminate at the anus located in the pygidium of the oldest stolon.

At first thought it would seem as though the buds of Trypanosyllis are more appropriately comparable to the sexual zooids of *Syllis ramosa.* The superficial resemblance to the latter is indeed striking. In both instances we have a lateral outgrowth of the stock, to which it is attached at the head end by a pedicle; in both, the zooids are the bearers of the sexual products (which do not develop in the stock), and both have an imperfectly developed prostomium bearing highly developed eyes. There are, however, two important points of difference: (1) the pedicle of the sexual zooid of *Syllis ramosa* is segmented, and the segments even bear rudimentary cirri[1]; (2) the sexual zooids as well as the asexual branches of *S. ramosa* contain a branch of the alimentary canal, fully continuous with that of the stock. In neither of these respects does the sexual bud of *T. gemmipara* in the least resemble the sexual bud of *S. ramosa.* The sexual zooids of the latter species are evidently specialized, fructifying branches of a widely branching asexual stock. They are equipped with large eyes and special swimming organs (natatory setæ), and break away from the parent stock at maturity. In all these respects they differ, it is true, from the purely vegetative branches, but these differences are merely adaptive to the special functions of insuring fertilization of the eggs and disseminating the species.

Whether the somite or somites from which the sexual buds of Trypanosyllis arise is to be regarded as homologous with the others cannot be decided from the material at hand. No

[1] M'Intosh. *Challenger Reports*, vol. xii (1887), Pl. XXXIII, Fig. 11.

somite unprovided with parapodia of the usual form was discovered. A recent study of *S. ramosa* by Oka[1] has brought out the interesting fact that the paired buds arise, not from one of the original somites, but from a newly developed, intercalated somite, which differs from all the others in lacking parapodia. Oka is doubtless right in regarding it as non-homologous with the other somites.

While the stolons of Autolytus and of syllidians generally are distinct and complete individuals provided not only with

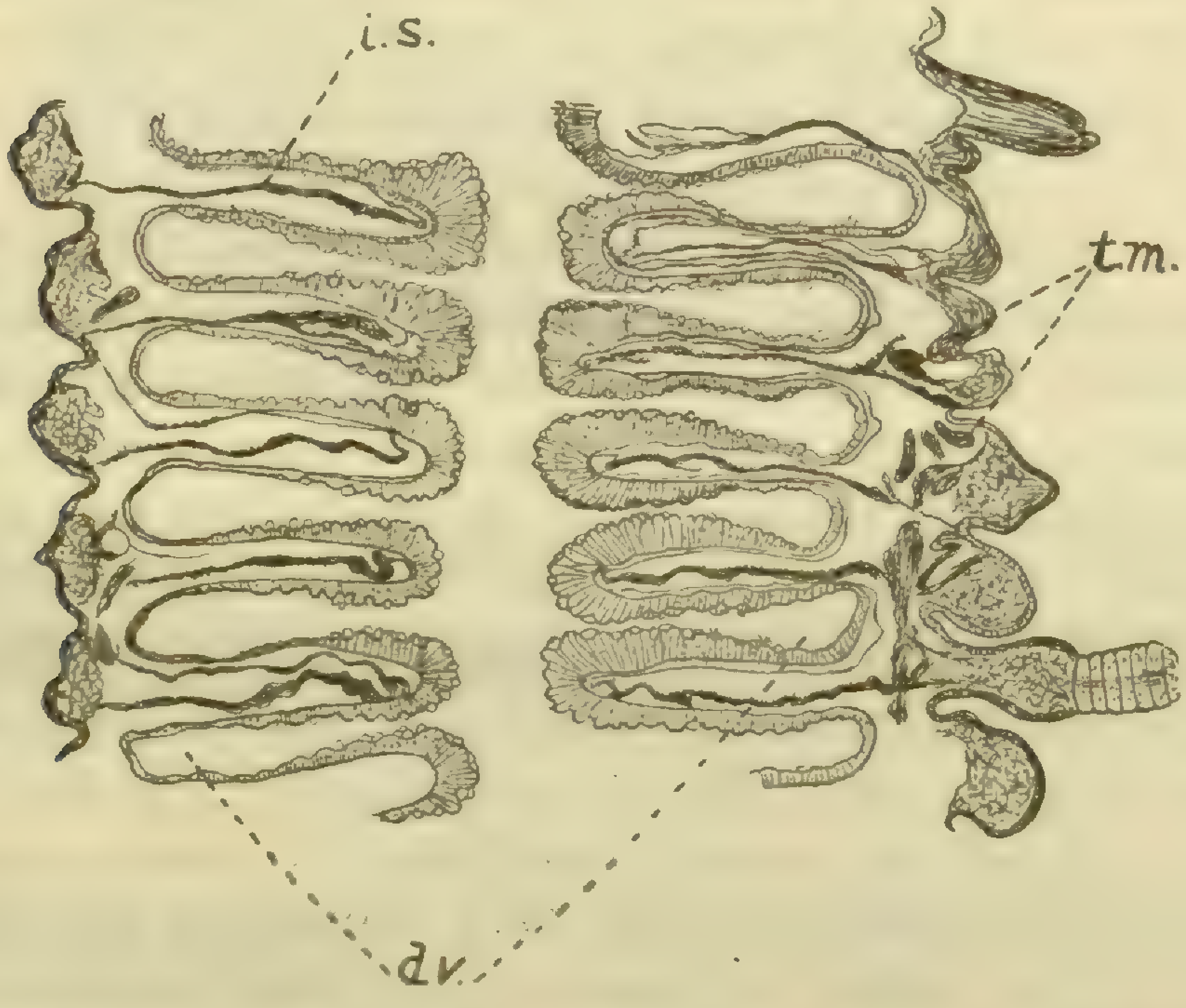


FIG. 16. — Frontal section of stock, *T. gemmipara,* showing the paired intestinal diverticula. The intestinal epithelium gradually thins towards the blind extremities of the diverticula. The intersegmental septa (*i.s.*) and some of the transversal muscles (*t.m.*) are shown. × 34.

sexual, sensory, and locomotor organs, but with those subserving nutrition, circulation, and excretion, the sexual buds of *T. ingens*, and even more strikingly *T. gemmipara*, exhibit a higher degree of specialization in lacking functionally developed vegetative organs. The zooid is therefore quite as incapable of leading a prolonged independent existence as the famed Palolo of the South Seas. It is no more than a living engine for the dissemination of the genital products which it carries,

[1] Oka, Asajiro. Ueber die Knospungsweise bei Syllis ramosa, *Zoölogical Magazine*, Tokyo, vol. vii (1895), p. 117.

and that duty must be accomplished solely by the expenditure of the stored-up energy which it has derived from the stock.

From the biological point of view the function of the zooids is the same, whether they arise by linear or by collateral budding. In both cases there is an alternation of generations exactly comparable to that of the Hydromedusæ. As regards *S. ramosa* the asexual stock is practically as sessile as the sponge in which it lives, and like sessile organisms of much lower grade it branches with great freedom and facility. It is not in the least surprising, therefore, to find such a form producing by lateral budding free-swimming zooids, which serve as special disseminators of the species and provide for a sexual reproduction in which cross-fertilization is assured.

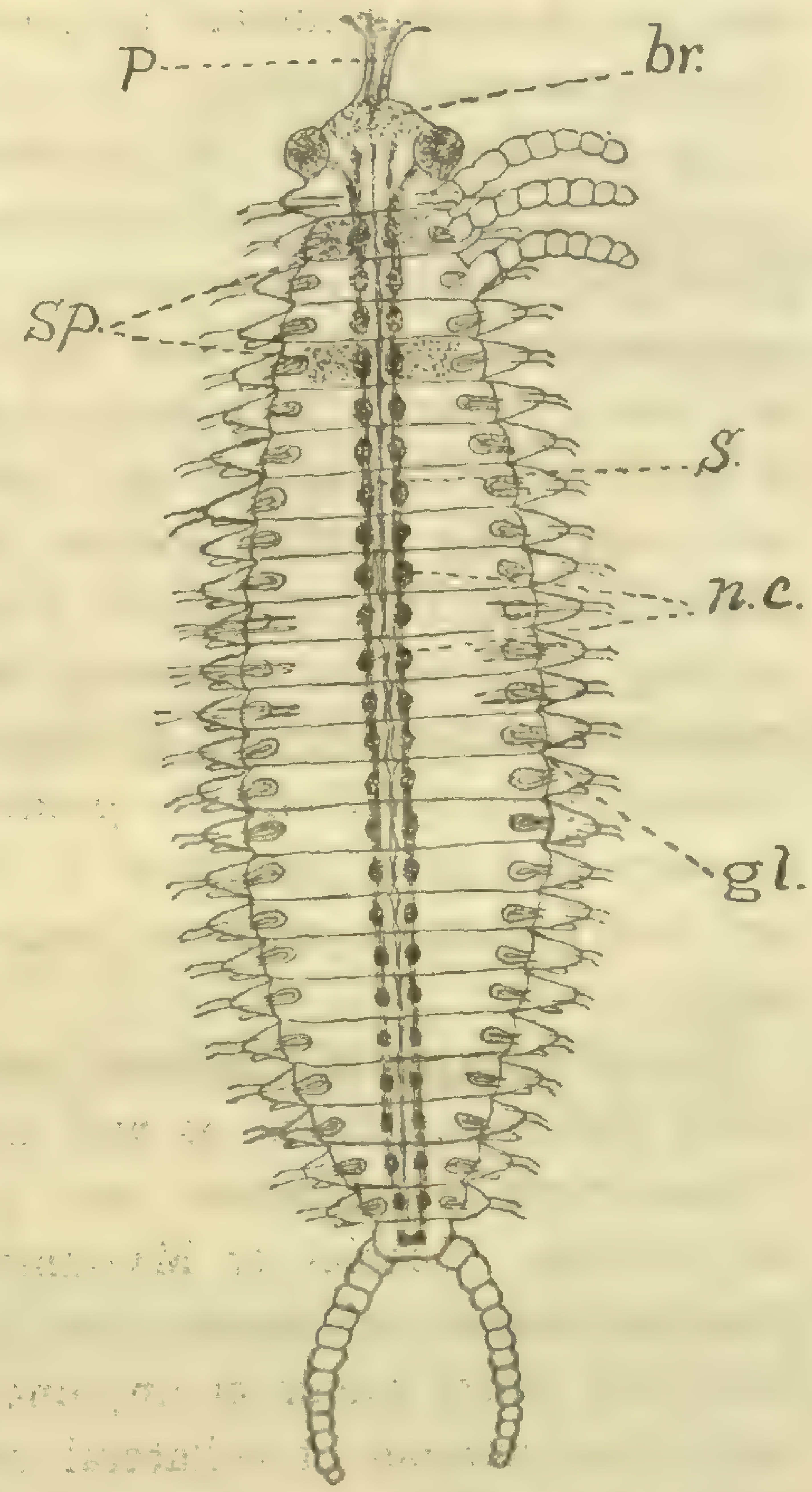


Fig. 17. — Ideal reconstruction of a mature male zooid of *T. gemmipara*. The dorsal cirri are omitted except on right side of three most anterior somites. The sperm masses are in every segment except the first and the pygidium, but are represented only in somites 2 and 5. The aciculæ are omitted except in first segment and three middle ones. *p.*, pedicle of attachment. Other lettering as in preceding figures.

In the forms under consideration the case is somewhat different. Notwithstanding their large size and heavy form, so different from the majority of syllidians, suggest that they are somewhat sluggish in their habits, neither of them can be considered as sessile. It is difficult to see, however, that they are any more inert than a multitude of annelids which have nothing aberrant in their mode of reproduction. Evidently some more precise explanation must be sought.

The fact that Trypanosyllis is a genus of the Syllidæ must not be overlooked. Of all the annelids, this family affords the best and most numerous examples of asexual reproduction by stolonization. The small size and comparatively simple structure of most syllidians no doubt peculiarly adapt them to this mode of multiplication. On account of its great advantage in the dissemination of the species, this form of reproduction, acquired by the presumably diminutive ancestors of the two gigantic species of Trypanosyllis, might be retained in a gradually modified form as by slow degrees the animal became larger and more complex. By equally slow degrees the collateral type of budding would replace the linear.[1] The development in both collaterally budding species of extensive intestinal diverticula (Fig. 16) in every somite from the proventriculus to the budding zone would obviously render inconvenient, if not impossible, the production of large gonads in the stock. As in many other syllidians the production of sexual cells would be more and more relegated to the most posterior somites, and to any linear or collateral buds that might develop in that region.

The advantages of collateral over linear budding in greater safety and compactness, as well as the possibility of securing a more rapid development and a greater number of buds, are obvious. Species of Myrianida produce stolons with the greatest number of zooids, but the chain is not known to have over thirty zooids at any one time.[2] This is only 60 per cent of the number of collateral buds present in the specimen of *Trypanosyllis gemmipara* that has been studied. The 50 buds of the latter add practically nothing to its length, while the 29 buds of the example of Myrianida figured by Malaquin form a chain no less than 55 per cent of the entire length of the worm. The liability to loss or injury to which such a

[1] In *T. zebra*, according to an observation recorded by Viguier in 1886 (*Arch. de Zool. Exp.*, sèr. 2, tome iv, p. 364, footnote), to which the author has kindly drawn my attention, there occurs an apparently non-terminal stolonization which perhaps is a step towards collateral budding. It is not well, however, to push the comparison very far, as there is really little likeness between the two types of gemmation as we know them at present.

[2] See Malaquin, *loc. cit.*, Pl. I.

lengthy chain would be exposed, particularly if very slender and attached to a stock of vastly greater bulk and strength, is evident.

The absence of organs of nutrition, the collateral mode of origin, and the fact that the smaller and simpler members of the genus still produce stolons point unmistakably to the high degree of specialization attained by the sexual zooids of these two species of Trypanosyllis. Both in their structure and in their mode of development they unquestionably represent the most specialized mode of asexual reproduction, not only among the Syllidæ, but among all known annelids.

THE COURSE OF THE BLOOD FLOW IN LUMBRICUS.[1]

J. B. JOHNSTON AND SARAH W. JOHNSON.

ALTHOUGH this form is almost universally used as a type for laboratory study, its circulation is still very imperfectly understood. The present contribution aims to give a better understanding of the course taken by the blood, as determined by observation and experiment upon large specimens of *Lumbricus terrestris*. The following brief review of the anatomy of the circulatory system, which is well understood, will serve as a basis for the discussion of the blood flow.

A large *dorsal vessel* extends along the dorsal surface of the intestine from the caudal end of the worm to the pharynx, over which it ramifies. Strong pulsations of this vessel run in more or less regular succession from the posterior to the anterior end. In somites VII to XI, inclusive, five pairs of circular vessels, the strongly pulsating *hearts*, encircle the œsophagus, connecting the dorsal vessel with the *ventral*. The ventral is a longitudinal trunk lying beneath the intestine and giving branches to the body wall and the nephridia. A *subneural* and two *lateral neural* vessels constitute, by reason of an irregular network of anastomoses between them, a connected system accompanying the nerve cord. This system is connected through branches of the lateral neurals with the body wall.

Connecting the dorsal and subneural vessels are the so-called *parietals*. They occur, one pair in each segment beginning with XII, close behind the septa and give off branches to the body wall and the nephridia. The parietal in somite XII is much larger than the others. In each somite two or more unpaired *ventro-intestinal* vessels enter the wall of the intestine from the ventral vessel, while two pairs of *dorso-intestinals* pass from the dorsal vessel into the wall of the intestine.

[1] From the Zoölogical Laboratory of West Virginia University.

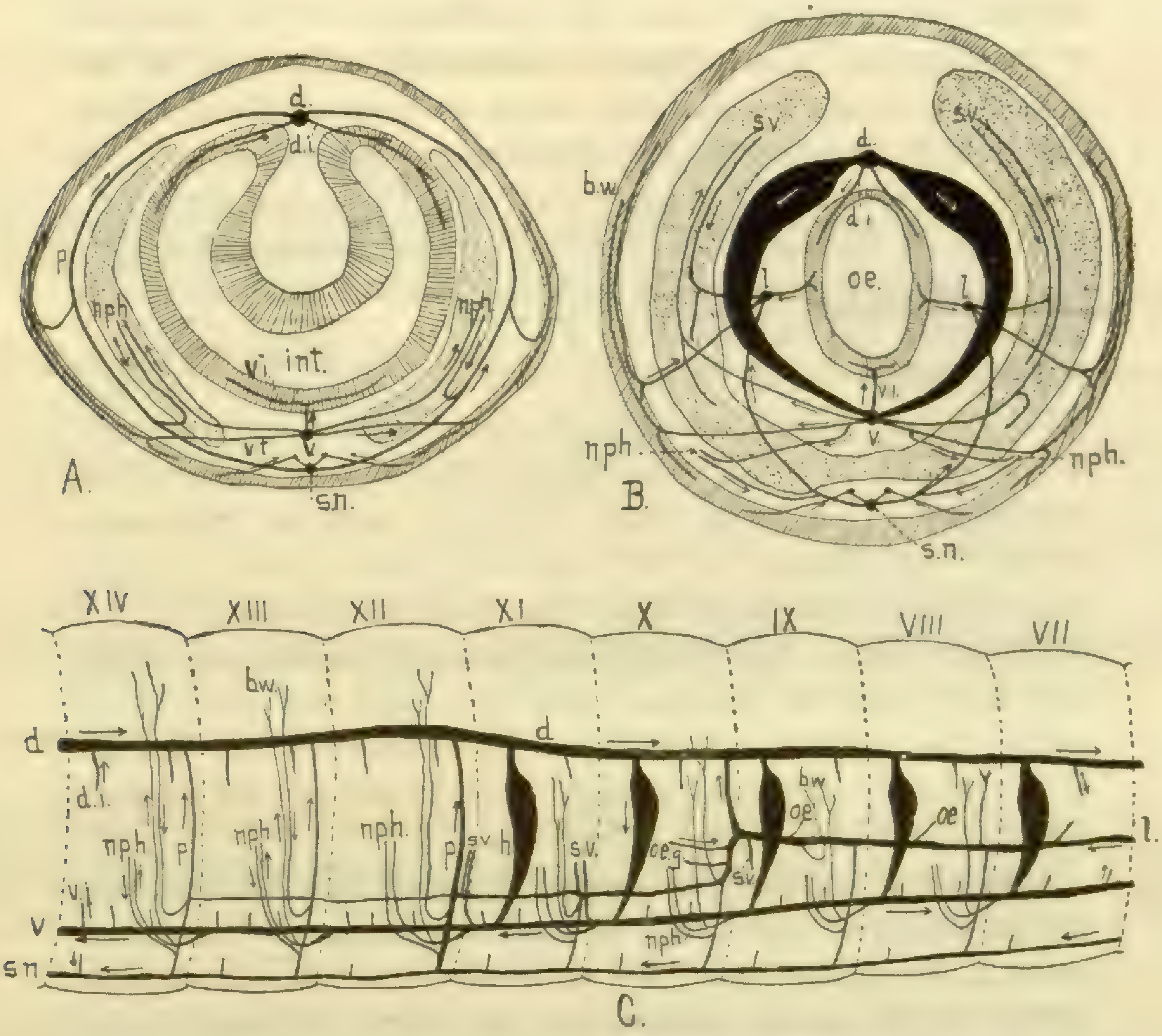
In somite X a pair of *lateral* vessels come from the dorsal vessel and run forward on either side of the œsophagus to the pharynx, giving branches to the œsophagus and body wall. An anastomosing vessel arises from the lateral near its origin in somite X and passes backward to join the large parietal in somite XII. From this anastomosis, branches supply the seminal vesicles, which are also supplied from the ventral vessel. Connecting vessels between the laterals and subneurals occur in several somites.

The only points with regard to the course of the blood flow upon which authors agree are that the blood flows forward in the dorsal vessel to the hearts, downward in the hearts, and backward in the ventral vessel. With regard to the further course of the blood Perrier came to the following conclusions (as reported by Bourne and Harrington): the blood flows into the dorsal vessel from the parietals and from it through the dorso-intestinals; the ventro-intestinals carry blood from the intestine to the ventral vessel; from the ventral it is given to the body wall and nephridia and is gathered up from these by branches from the lateral neurals and parietals; the flow in the laterals is forward.

Bourne (**'91**) studied the blood flow in Megascolex principally by holding the vessels with forceps and by cutting them to see from which cut end the blood flowed. His conclusions are nearly opposite to those of Perrier, namely, that the dorso-intestinals empty into the dorsal and the parietals carry blood away from it; the ventral gives blood to the intestine through the ventro-intestinals; it also gives blood to the body wall and nephridia, from which it is carried to the intestine (in Megascolex) by the intestino-tegumentaries. The lateral vessels carry blood backward.

Benham (**'91**), working on Lumbricus, agrees with Perrier in regard to the blood flow in all vessels.

Harrington (**'99**) has given a full account of the anatomy of the vascular system, with elaborate figures. His descriptions and figures, however, do not always agree, *e.g.*, the common vessel branching into ventro-tegumentary and ventro-intestinal described on page 142 is not shown in the figures. Harrington



DIAGRAMS TO ILLUSTRATE THE SCHEME OF CIRCULATION GIVEN IN THIS PAPER.

A, cross section of body region; *B*, cross section through hearts; *C*, sketch of vessels in somites VII to XIV seen from the side. Arrows indicate the direction of blood flow. *b.w.*, body wall and vessels supplying it; *d.*, dorsal vessel; *d.i.*, dorso-intestinals; *h.*, hearts; *int.*, intestine; *l.*, lateral vessel; *nph.*, nephridium and vessels supplying it; *œ.*, œsophagus and vessels supplying it; *œ.g.*, vessels supplying œsophageal glands; *p.*, parietals; *s.n.*, subneural; *s.v.*, seminal vesicles and vessels supplying them; *v.*, ventral vessel; *v.i.*, ventro-intestinals; *v.t.*, ventro-tegumentaries. The figures are unfortunately crowded, owing to the projection on one plane of many vessels which lie at different levels. The lateral neurals are not lettered in *A* and *B* and are not shown in *C*.

was the first to describe the arrangement of vessels to the integument, showing that the capillaries of the parietals ("commissurals") are directly continuous with those of the ventro-tegumentaries, and that loops of these capillaries lying just beneath the cuticle have the function of respiration. He has shown also that in somites VIII to XIII inclusive the subneural has a branch which supplies the nephridium and setigerous glands and anastomoses with the lateral. The lateral has connections with the dorsal in X and XII, as above described. Anastomosing vessels continue backward through XIII and XIV, making connections with the subneurals at each septum. These points have been verified by the present writers, but Harrington's statement that the true parietals ("commissurals") are absent in XIV and XV they cannot confirm. True parietals are always found in all somites back of XII, and occasional worms clearly show anastomosing vessels continuing backward from the laterals, connecting with the parietals of one or two somites. The anastomoses between the laterals and subneural have not always been found by the present writers in all the somites mentioned.

Harrington studied the course of blood flow by watching the pulsations of the vessels in small specimens of Lumbricus under a dissecting lens. He concludes that the blood flows forward in the dorsal, downward in the hearts, backward in the ventral, into the dorsal from the dorso-intestinals and out from it into the parietals ("commissurals"), forward in the laterals, and either forward or backward in the subneural.

The senior author has made observations on the course of the blood flow in connection with class work for a number of years. During this time the direction of flow in the subneural has been demonstrated in many student dissections, the result constantly agreeing with that stated below. The observations reported here have been made on the largest worms obtainable, anæsthetized and opened under physiological salt solution. The course of the flow in each vessel has been determined by the three methods of clamping, cutting the vessel, and watching the pulsations where these are visible. Injecting the dorsal vessel was tried several times, but as yet no facts

regarding the course of the flow have been made out by this means, although the injection gives a good demonstration of the anatomy of the vascular system.

Description of Experiments.

Many experiments give no definite results, owing to the condition of the worm or to violent disturbance of the circulation. Great care is required in recognizing and interpreting the results, especially in observing pulsations. It has been found that when fairly clear and definite results are obtained, the same result is given by the different methods.

1. *The Dorsal Vessel.* — The fact that the blood flows forward in the dorsal vessel up to the hearts is clearly shown by the course of the pulsations. In front of the hearts the pulsations are not conspicuous, and special attention was given to determining the course of flow in this part of the dorsal. Among the many worms dissected a few were found in which the pulsations of the dorsal were distinctly seen running forward to the pharynx. The dorsal vessel was clamped in front of the hearts in a number of worms, and in all cases the blood collected behind the clamp and disappeared in front of it. The blood flows forward throughout the whole length of the dorsal.

2. *The Ventral Vessel.* — The experiments noted below and the general agreement of authors make it certain that the blood flows backward in the ventral vessel back of the hearts. The course of the flow in front of the hearts was shown by clamping the ventral vessel in the seventh somite. In every case the blood collected behind the clamp and disappeared in front of it, indicating a forward flow.

3. *The Subneural and Lateral Neurals.* — The best results are obtained on these vessels by opening the worms from the ventral side. When the subneural vessel was cut the blood flowed only from the anterior cut end, *i.e.*, backward. The same result was obtained constantly by pinching the subneural with forceps: the blood collected very distinctly in front of the forceps and disappeared behind them. These experiments were tried in all regions of the worm.

4. *The Parietals.* — Clamping these vessels has given doubtful results. The first experiments were made by pinching them at about the middle of their length in a number of worms. The blood seemed to collect between the dorsal vessel and the forceps. More recently no results whatever have been obtained from the parietal vessels by this method. This is perhaps due to the fact that branches from the body wall enter the parietals both above and below the forceps. In each of eight worms a dozen or more parietal vessels were cut, and in every case in which bleeding occurred the blood flowed from the lower end, that is, toward the dorsal vessel.

Owing to the numerous connections of the parietal vessels, it is necessary to use indirect methods to determine the course of blood flow in them. In several sets of experiments the attempt was made to determine the source of supply to the parietals and their place of emptying, by clamping or cutting other vessels. All three longitudinal trunks, dorsal, ventral, and neural, were simultaneously clamped, with the following results in each case. The dorsal vessel was filled on both sides of the clamp. Although the pulsations were sometimes seriously interfered with, its normal fullness was maintained. This is to be explained, as will appear from what follows, by the fact that in front of the clamps a complete circulation is kept up and the fullness of the dorsal maintained by the dorso-intestinals and parietals *both* emptying into it. On the theory that the parietals and dorso-intestinals carry blood in opposite directions, it must be expected that the dorsal would be empty in front of the clamp in this experiment. If only one set of circular vessels empty into the dorsal, its own pulsations together with the other circular vessels must certainly drain it of blood in front of a clamp. Behind the clamp it is to be expected that the dorsal should be full, but the normal fullness is not greatly exceeded, because the clamping of the ventral and neurals cuts off the supply of blood to the posterior end of the worm. It is also possible that the course of flow is reversed in the parietals or dorso-intestinals or both, just behind a clamp on the dorsal, because of the excessive pressure developed by the pulsations of the latter vessel. In this

experiment the ventral and neural vessels were filled in front of, and empty behind, the clamps, indicating a backward flow in both. The parietals were filled both in front and behind the clamp. They were somewhat distended in front of the clamps, owing to increased pressure from the subneural in front of its clamp, while behind the clamps the parietals continued to collect some blood from the body wall and nephridia.

In four worms the ventro-intestinals in several segments were cut in order to drain the intestine of blood in those segments, and the dorsal was afterward clamped at both ends of the area in which the ventro-intestinals were cut. Between the clamps the dorsal decreased and the parietals were normally full. In four other worms the same result was reached when the dorsal was clamped in one place and the dorso-intestinals were cut for several segments in front of the clamp. Since the dorsal retained some blood and the parietals kept up their normal fullness as long as the worm lived, while all other supply to the dorsal was cut off, it is impossible to reach any other conclusion from these experiments than that the parietals bring blood to the dorsal.

Pulsations of the parietal vessels are not always clearly visible. In four worms in which the pulsations of the parietals were distinct and strong a large number of these vessels were carefully studied. The contraction of the parietals occurs opposite the front part of the pulse wave of the dorsal, *i.e.*, while the dorsal is reaching its greatest fullness. The parietals fill just after the contraction of the dorsal, *i.e.*, opposite the point of constriction of the dorsal behind the pulse wave. The filling of the parietals is sudden and the contraction slow. This, taken together with the order of the contractions, indicates that the contraction of the parietals helps to swell the dorsal just in front of the constriction which carries its pulse wave along, while the rapid filling of the parietals is due to the sudden closure of the parieto-dorsal openings by the contraction wave of the dorsal. The results of all the experiments considered together strongly favor the conclusion that the parietals carry blood to the dorsal.

5. *The Dorso-Intestinals.* — When one clamp was put on the dorsal vessel and a number of parietals were cut just in front of it, the dorsal vessel only partly emptied; but when the dorso-intestinals in the same segments were cut the dorsal vessel emptied entirely. This and the experiments on the parietals described above, in which the cutting of the ventro-intestinals in one case and of the dorso-intestinals in another resulted in the decrease of the dorsal vessel in those segments, show that the dorso-intestinals carry blood to the dorsal.

6. *The Lateral Vessels.* — When the laterals are clamped either at both their connections with the dorsal in somites X and XII or in front of the connection in X, they remain full of blood, sometimes much distended, in front of the clamps. No vessels have given more positive and unmistakable results than these.

Criticism and Conclusions.

There is no difference of opinion in regard to the blood flow in any part of the dorsal vessel. All authors agree that it flows forward to the extreme anterior end of the worm.

Bourne alone suggests that the blood flows forward from the hearts in the ventral vessel, since he considers that the strong contractions of the hearts would force blood forward as well as backward. Our experiments have confirmed this plausible view, and it may be regarded as proved that the blood flows forward in this part of the ventral.

Although previous workers have not agreed upon the functions of the parietals and dorso-intestinals, they all agree in assigning to these vessels opposite functions. The above experiments on the parietals, although not wholly decisive, give strong support to a different conclusion, namely, that both parietals and dorso-intestinals carry blood to the dorsal.

It follows necessarily that the ventro-intestinals supply the intestine with blood, as Bourne and Harrington contend.

According to Harrington's interpretation all of the blood in circulation would have to pass through the ventro-intestinals; in other words, all of the blood which is carried forward by the dorsal and all that which passes downward from the dorsal in

each somite through the parietals must be carried to the dorsal by the ventro- and dorso-intestinals. It does not seem possible for all of the blood to take this course, owing to the small size of the intestinal vessels. It has been impossible for the present writers to arrive at a definite conception of the blood flow according to Harrington's scheme. He represents the blood as flowing in different directions in different parts of the same vessel, and as changing its direction in the same vessel from time to time. Our experiments give no confirmation whatever to either of these conclusions, except that the direction is permanently reversed in the front end of the ventral vessel and in the dorso-intestinals in front of the hearts as above described. Temporary reversal of the flow in limited regions might easily occur as a result of the animal's movements, and such phenomena may have led Harrington to erroneous conclusions, since he worked only by studying the pulsations through the skin with a hand lens. His scheme of the circulation is full of inconsistencies, due either to an attempt to avoid overloading small vessels and consequent breakdown of the scheme, or to the incomplete study of several genera, resulting in a patchwork which is not true for Lumbricus at least. It is but proper to say that these inconsistencies might have been removed had the author lived to see his work through the press.

Bourne states that the lateral vessels carry blood backward, Harrington that they carry it forward. Our results positively support Bourne's view and, together with the results on the parietals, suggest a new interpretation of the morphology of the lateral vessels. Bourne considers them to be the subneural ends of the parietals in this region, *but assigns to them an opposite function.* The following facts seem to show that the lateral vessels are formed by anastomoses between successive parietals, which carry the blood from the head region to the dorsal in somites X and XII, and that the lateral system therefore represents the parietals in the head.

1. Absence of true parietals in front of somite XII.

2. Connections of the laterals with the subneural in several somites (VIII–XIII) which correspond perfectly to the ventral

ends of parietals, having branches to the nephridia as the parietals do.

3. Connections of the laterals with the dorsal in somites X and XII, corresponding to the dorsal ends of parietals.

4. Anastomoses between the parietals of somites XII, XIII, and XIV, in apparent continuation of the laterals.

5. Presence of branches of laterals to the body wall along the septa, corresponding to respiratory branches of the parietals.

6. Presence of branches to the seminal vesicles, which are also supplied by branches from the ventral. Here, as elsewhere, branches of the parietals take up blood which is brought from the ventral. The parietals are in the best position to supply the vesicles which are developed from the septa.

The origin of the hearts and laterals and the position of the laterals within the circular hearts are problems which require more facts for their solution. An extended discussion of them is beyond the province of this paper, but one or two suggestions will be made. The suggestion of Harrington that the hearts are modified parietals is negatived by the presence of both parietals and hearts in somite X, and by the different ventral connections of the parietals and hearts. It seems more probable that the hearts are enlarged circular intestinal vessels, serving to carry the blood brought forward by the dorsal. The lateral vessels must have arisen as anastomoses between successive parietals serving to return the blood from the head (brought forward by both dorsal and ventral), to the dorsal behind the hearts. The dorsal connections of the parietals in front of the hearts have disappeared from disuse. The position of these anastomoses within the circular hearts seems to indicate that they, too, have been derived from the capillaries of the œsophageal wall, although later than the hearts. This suggestion would explain the branches of the lateral vessels to the œsophagus and hearts, which otherwise are unexplained.

Conclusions. — The course of the circulation in each segment behind the hearts is as follows: the branches of the lateral neurals and parietals collect blood from the body wall; the parietals take blood to the dorsal from the subneural, body

wall, and nephridia; the dorso-intestinals give blood to the dorsal from the intestine; all of this blood goes forward in the dorsal to the hearts; through them nearly all of it is given to the ventral vessel, which sends it to the intestine through the ventro-intestinals and to the body wall through the ventro-tegumentaries.

The head region is supplied with blood by the dorsal and ventral vessels, and the neurals and laterals carry blood from it.

The dorsal and ventral vessels carry mixed blood, the dorsal receiving oxygenated blood from the parietals and non-oxygenated from the dorso-intestinals. The neurals carry oxygenated blood only. The dorsal and ventral vessels carry mixed blood to the head region; the laterals carry backward mixed blood, and the neurals oxygenated blood.

There is no support given by our experiments to the idea of a more or less complete segmental circulation in Lumbricus. The circulation is strictly systematic, the blood making a complete circuit from the hearts backward through a greater or less number of somites, upward through the body wall, nephridia, or intestinal wall, to the dorsal, and thence forward to the hearts. This scheme of circulation is simple, and the slight modifications of it, which occur in the head region only, have received at least an attempt at explanation above. The interesting and highly important question presents itself: What happens when a worm's head is cut off and it lives and regenerates a new head, or perchance a tail? With the removal of the hearts some substitute must be provided to carry the blood from the dorsal to the ventral vessel. A series of regeneration experiments have been begun to find the answer to this question.

October 23, 1901.

LIST OF PAPERS CITED.

PERRIER (reported by Bourne and Harrington).

'91. BENHAM, W. B. The Nephridium of Lumbricus and its Blood Supply. *Quart. Journ. Micr. Sci.* Vol. xxxii, p. 293.

'91. BOURNE, A. C. On Megascolex cœruleus and a Theory of the Course of the Blood in Earthworms. *Quart. Journ. Micr. Sci.* Vol. xxxii, p. 49.

'99. HARRINGTON, N. R. The Calciferous Glands of the Earthworm, with Appendix on the Circulation. *Journ. of Morph.* Vol. xv, Supplement, p. 105.

NOTES AND LITERATURE.

GENERAL BIOLOGY.

Organic Regulations. — Hans Driesch publishes, under the title of *Die organischen Regulationen*,[1] a pamphlet of 228 pages which deals with a number of organic phenomena, some of which are better known as adaptations, others as restitution of form and of function. The subordinate title of the paper, "Vorbereitungen zu einer Theorie des Lebens," indicates the ambitious aim of the author.

The contents are arranged under three headings: I, Descriptive Part; II, Theoretical Part; III, Critique of Knowledge.

I. In the first part we find a description given of metabolic regulations (adaptations), of morphological adjustments to the environment, and of restitution or restorative regulative processes. An attempt is made to sift out the essential features of these phenomena.

II. In the theoretical part the different kinds of regulations are classified, the relation between regulations and stimuli is discussed, and an analysis of form regulation is attempted. Under this same heading a section is entitled "Thoughts on Respiration and Assimilation." Here an hypothesis of the "real" meaning of the process of oxidation in organisms is suggested, and a curious inquiry is made into the fundamental but almost unknown field of assimilation. Then follow two "proofs" of vitalism, or, as the author prefers to call the latter, "The Autonomy of the Life-Processes."

The first proof of the autonomy of the life process is an extension of the same argument previously employed by Driesch, and deals with "The Differentiation of Harmonic Equipotential-Systems," or, more simply, with the formation of a new whole organism from a piece of an egg or from a piece of an original organism, — the piece having in both cases the potencies of the original whole in all its parts.

The second proof of vitalism is found in "The Genesis and Existence of Equipotential Systems with Complex Explicit Potencies." The author believes "it is impossible that a complicated structure (*Tektonic*) made up of many definitely arranged parts (*Specifitäten*)

[1] Driesch, Hans. *Die organischen Regulationen:* Vorbereitungen zu einer Theorie des Lebens. Leipzig, W. Engelmann, 1901. 228 pp.

differentiated in three dimensions could divide itself by material means into the elements of an equipotential system." "If each organism produced but one egg, then the materialistic conception of heredity might be true, in which case there need not be of course a regulative restitution; but since the organism produces many eggs, the conception is impossible; because, (I), in order that the developmental phenomena may be deduced materialistically they must be thought of under the assumption of a complicated primary machine, but, (II), on account of the required division of the complex potencies into the elements this assumption cannot be made."

Perhaps these statements may be clearer in the following quotation, in which both the first and the second proofs of the autonomy of the life process are considered together. "The preceding phenomena can be interpreted only on the basis of machines of a complicated sort — but such machines can, for other reasons, not exist. They cannot exist, in the first place, because a machine does not remain the same when we take away any of its parts, or when we rearrange its parts; for machines do not possess the property of division." It can scarcely be claimed by the author that the discovery that organisms are not machines is new, but having admitted this, it does not seem to follow that, therefore, there must be a vitalistic principle in nature. There seems to us to be a great hiatus in Driesch's argument, and in any case his conclusions appear to be based rather on our ignorance of what the organism really is than on a demonstration that it is something that cannot be conceived under a causal-mechanical point of view.

III. In the final section of the paper a number of philosophical and metaphysical topics are discussed, and the author defines his position in regard to the use and meaning of the terms "mechanism" and "causality."

ZOÖLOGY.

Fauna of Switzerland. — The origin of the present fauna of Switzerland from that of the glacial period has been the subject of repeated investigations, but these studies were mainly restricted to the higher forms of terrestrial life. A recent publication by Prof. F. Zschokke[1] not only gives a condensed review of our knowledge

[1] Zschokke, F. *Die Tierwelt der Schweiz in ihren Beziehungen zur Eiszeit.* Basel, 1901.

of the origin of the Helvetian fauna in general, but preëminently applies the views gained by previous studies to the lower forms of animals that inhabit the fresh-water lakes, streams, etc., of the country.

Professor Zschokke points out that the present terrestrial fauna and the present flora belonging to the high mountain regions of the Alps find a counterpart in the arctic regions, the identical species being in many cases represented there. These two main ranges are in some degree connected by intermediate, but isolated and discontinuous, stations on the highest elevations of the intervening low countries, or in localities which, owing to local conditions, possess a particularly cool climate (for instance, peat bogs). It is generally agreed that this peculiar distribution is to be explained as a remnant of the glacial period. During the latter the originally alpine and arctic fauna and flora was widely distributed over the low countries of central Europe, where it found congenial climatic conditions. After the close of the glacial period, at the commencement of a warmer climate, this glacial fauna and flora retreated in two directions: toward the north pole, and toward the high mountains to the south; while in the intervening parts it remained only in a few scattered colder localities, such as the highest summits of the mountains of central Germany. The parts evacuated by this arctic element were occupied by a new stock of life that immigrated chiefly from the east (Siberia).

This is true for plants and terrestrial animals, such as mammals, land mollusks, insects, reptiles; and in many cases we have direct means of ascertaining and verifying this process, since we know glacial and interglacial remains of the respective forms that have been found in the low parts of central Europe.

While it thus seems positively assured, by paleontological facts, that the origin of the alpine flora and terrestrial fauna of Switzerland is to be traced back to glacial times, and lies in the vast country bordering the ice sheet that covered north Europe to the south, we have no such evidence as regards the fresh-water fauna. Nevertheless, Professor Zschokke demonstrates that the distribution of many fresh-water animals of the alpine lakes and streams of Switzerland exhibits the identical peculiar features that are known in terrestrial animals; they reappear in arctic fresh-water basins offering the same climatic conditions, and are wanting in the intermediate tracts except for a few scattered and exceptionally favorable localities. From this similarity in distribution we are to infer that the origin of the distribution of these fresh-water forms was subject to the same laws.

But there is an important difference of the fresh-water fauna from the terrestrial. In the latter, the different faunas, the old glacial and the newer postglacial, are, in the mountains, so to speak, on top of one another, the postglacial fauna occupying the lower parts and ascending the mountains only to a certain elevation, where it gives room to the older fauna, which has taken to the summits. In the fresh-water fauna, however, there is a much larger degree of intermingling; indeed, the postglacial immigrants have been able to reach the most exposed and highest stations in the mountains, and are found everywhere in close vicinity and association with the older glacial elements. According to Zschokke, this fact is due, on the one hand, to the character of the immigrants, which are cosmopolitan, eurytherm forms of life, which may find congenial conditions of existence anywhere; on the other hand, it is due to the peculiarities of temperature in the fresh-water bodies, where the extremes are not so much contrasted and lie closer together than those of the air influencing the terrestrial animals.

The old glacial fauna of the glacial time did not only retreat in these two directions mentioned, but there is a third *refugium* for those that belong to the fresh water. In the depths of the great lakes that fringe the northern foot of the Alps, similar conditions of temperature prevail as in glacial times everywhere in fresh water. These cold depths contain a fauna consisting of peculiar fishes (Salmonidæ) and crustaceans (the latter chiefly pelagic) that point distinctly to a northern origin. These forms apparently immigrated at the close of the glacial period, when there was an abundance of cold water derived from the receding ice. Later, after the abundant supply of water had given out, these forms were cut off from the communication with their northern homes, and their only chance to survive was in these large and cold fresh-water lakes, which resemble their original home at least in temperature.

Thus we may distinguish, among the fresh-water fauna of Switzerland as well as among the terrestrial fauna, two elements: (1) an old glacial stock that lived during the glacial period all over the inhabitable parts of central Europe; and (2) a later immigration in postglacial times. The first one retreated out of the plains in two directions: toward the north pole and toward the mountains. But while for the terrestrial animals which fled to the highlands no other way was left than to go upward, for some of the fresh-water animals a third asylum was open: the deep and cold fresh-water lakes on the northern border of the Alps.

A. E. O.

North American Finches.[1] — This work, when complete, will of course be the standard book of reference on North American birds. It represents the matured views of our foremost ornithologist and is remarkable for the clear and terse, yet ample, manner in which the facts are presented. It includes not merely the birds of the United States and Canada, but also those of Central America, Mexico, the West Indies, and the Galapagos Islands. A full bibliography is given for every species and subspecies; and there are numerous measurements of specimens from different localities, indicating slightly variant forms not designated by special names.

The present volume includes the sparrows and finches. Excluding the Galapagos genera, and three species introduced from Europe, we have 186 species, to which are added 165 subspecies, making 351 named forms in all. The species may be divided thus:

1. Monotypic species in monotypic genera . . . . . . 13.
2. Polytypic species in monotypic genera . . . . 8.
3. Monotypic species in polytypic genera . . . . 106.
4. Polytypic species in polytypic genera . . . . 59.

Total monotypic species, 119; polytypic species, 67.

A monotypic genus is one which has only a single species; a monotypic species is one having only one form, *i.e.*, without subspecies.

The monotypic genera of the first group are distributed thus:

1. Great plains of North America: Rhynchophanes, Calamospiza, Centronyx.
2. Mountains of Western North America: Oreospiza.
3. Mexico and Central America: Plagiospiza, Pselliophorus, Pezopetes, Acanthidops, Rhodothraupis.
4. Cocos I., off Bay of Panama: Cocornis.
5. West Indies: Melanospiza (St. Lucia), Loxipasser (Jamaica), Loximitris (Haiti).

It is significant and interesting that there are no monotypic genera with monotypic species east of the great plains; or, excepting Oreospiza, west of them to the Pacific. The conditions in the west, which have produced so many distinct species and subspecies, have not yet given us, in the groups under consideration, new generic types. In other words, the evolution of the peculiar western genera antedates the comparatively recent development of local specific forms. This agrees very well with the results obtained from the study of other groups, *e.g.*, the flowering plants. We find numerous closely allied

[1] Ridgway, Robert. The Birds of North and Middle America, Part I, *Bull. No. 50. U.S. Nat. Mus.*, 1901. 715 pp., 20 pls.

species belonging to old and widespread genera, pointing to a recent period of plasticity of types, not going so far, however, as to affect the genera. For the development of new genera, environmental conditions of great stability and complexity, such as exist to-day in the tropics, seem to be most favorable; and it may very well be that most of the distinctive North American genera had their origin at a time long previous to the glacial period, when such conditions more nearly prevailed on this continent. The changeable conditions of recent periods, while extremely favorable to the production of new subspecies or even species, might from their very instability be inimical to the development of new genera.

It is interesting to observe how much more plastic some species are than others. Thus, in the genus Melospiza, *M. lincolnii* and *M. georgiana*, though very widespread, remain monotypic, while *M. cinerea* has split up into no less than twenty-one subspecific forms, many of very restricted distribution.

A very interesting discussion is given of the Galapagos genus Geospiza. This includes twenty-seven forms, the extremes of which are so distinct that they used to be assigned to different genera; yet the gradation from one to the other is almost complete. Messrs. Rothschild and Hartert proposed to regard a number of these forms as subspecies of the others; but Mr. Ridgway urges that there is really no alternative between regarding them all as forms of one species and treating them all as specific units. Since the former course is one that would commend itself to no one, the latter is adopted, with the result that we have a series of "species" far more intimately related than the forms usually classed in this category. We feel much as we might feel if suddenly confronted with the whole series of extinct types connecting our very "good" genera and species of the present day. Were the Galapagos less isolated, and the competition with other groups of birds more severe, no doubt several of the links would be conveniently missing by this time, and we should not have occasion to dispute over the status of the remainder.

Many endemic forms are recorded from the islands of the California coast and the West Indies. These are in most cases regarded as subspecies only; though, in the inevitable absence of intermediate series occupying the intervening territory (this being water), it would seem more logical to treat them as distinct species. We seem to need a new term to express these allied insular forms; but since their continuity with the parent species is assuredly broken, I would rather write

the names as binomials; *e.g.*, *Pyrrhulagra ridgwayi* for *P. noctis ridgwayi* Cory; *Melospiza graminea* for *M. cinerea graminea* (Townsend).

A very singular case is that of *Euetheia bicolor omissa*, occupying most of the West Indian Islands, but replaced in Jamaica, Haiti, Barbados, and Grenada by *E. b. marchii*. Are we to suppose that the latter once occupied the whole chain of islands but has given way to the former wherever it appeared upon the scene?

Two statements in the work seem to call for special comment. One is as follows: "The necessity for beginning this work with the highest instead of the lowest forms is to be regretted, and may be explained by briefly stating that owing to inadequate facilities for properly arranging the larger birds in the National Museum collection these are not available for study, and consequently it became necessary either to begin with the smaller birds, already systematically arranged, or else postpone the work indefinitely."

That such a statement should be made regarding our National Museum may well make us feel ashamed. Is this country too poor to provide facilities for such a man as Mr. Ridgway, who returns to it a thousandfold the small means it has placed at his disposal? Are we so blind that we cannot see that scientific knowledge is more than the equivalent of money; is not merely convertible into that medium, but is in itself far more nearly an end of national existence, since it adds to the worth of the individual himself, and not merely to the worth of that which is temporarily attached to him?

The other statement referred to is quite different. We are told: "There are two essentially different kinds of ornithology: *systematic*, or *scientific*, and *popular*. The former deals with the structure and classification of birds, their synonymies and technical descriptions. The latter treats of their habits, songs, nesting, and other facts pertaining to their life-histories." The present writer has to confess that this statement quite took his breath away. The study of living birds, then, is "popular," but the study of their mortal remains, stuffed with cotton and provided with tags, or occasionally, perhaps, immersed in alcohol, — this is "scientific." It is hardly possible that Mr. Ridgway could have intended his words to be taken literally. No one could deny that Mr. Ridgway's work on museum material is in the highest degree scientific, and we may freely admit that nine-tenths of what is written on the habits, nesting, etc., of birds is much less so; but it surely does not follow that the story of life histories is in the least degree less scientific, in itself, than any other branch of ornithology. One might as well say that the study of alcoholic

brains is scientific (because the literature of that subject is so), but the study of mental processes is popular, or non-scientific, for the reason that we have a mass of trivial literature on psychology.

T. D. A. C.

Notes on Fishes. — In a recent visit to San Diego the writer saw in the possession of an animal artist, Miss Annie Andrews, good paintings of the threadfin, *Polydactylus approximans*, and the sea bonito, *Gymnosarda pelamis*. The threadfin is common about Mazatlan, but had never been taken in the limits of the United States. It was once described as *Polynemus californiensis* by Thominot, from "California"; but that California which stretches from Rogue River to Cape San Lucas is zoölogically very indefinite, comprising three distinct marine faunas. The oceanic bonito is common at Honolulu and in Japan, and was once before noticed by Eigenmann at San Diego.

In the *Scientific American* for December 21 Mr. C. F. Holder publishes a photograph of *Luvarus imperialis*, a large and rare fish of the Mediterranean, lately taken at Avalon on Santa Catalina Island, off the coast of California. There is no question as to the identity of the species with the genus Luvarus, and no specific difference appears in Mr. Holder's photograph, a copy of which the writer has seen.

Mr. Holder also reports that he has seen two specimens of the oarfish, *Regalecus* (*russelli ?*), taken in Avalon Bay. One of these, two feet long, was examined by him while alive. "Its topknot," Mr. Holder says, "was a vivid or scarlet mass of plumes. The dorsal spines, which merged into a long dorsal fin, extended to the tail. The color of the body was a brilliant silver sheen, splashed with equally vivid black zebra-like stripes." Mr. Holder was unable to obtain either specimen, the finders insisting on placing them on a piece of board to be dried in the sun as "curios." In this condition the water soon evaporated, and practically nothing was left.

In *Science* for Dec. 13, 1901, Gill and Townsend give an account of a large fish about five feet in length, dredged by the *Albatross* at a depth of 1050 fathoms off the Chonos Archipelago in Chile. By some accident the huge specimen was cast overboard, and the description is made from a photograph. The fish is of trachinoid affinities and is perhaps one of the Percophidæ. The name given it is *Macrias amissus*. The recent explorations of Dollo show that

in the deep seas of the Antarctic, as well as the shore waters, trachinoid fishes related to Percophis and Notothenia are numerous and characteristic.

In the *Proceedings of the New England Zoölogical Club*, Mr. Samuel Garman shows that the Japanese deep-water Chimæra described by Professor Mitsikuri as *Harriotta pacifica* is the type of a new and still more primitive genus, which he calls Rhinochimæra. It differs from Harriotta by the possession of teeth like the horny covers of the jaws on tortoises and birds, without the separate tritors found in Chimæra, Harriotta, and Callorhynchus. Garman divides the group into three families, Chimæridæ, Callorhynchidæ, and Rhinochimæridæ, the latter including Harriotta. Garman makes the important discovery that the frontal holder or cartilaginous hook on the forehead of the male is present on the adult of Harriotta and Rhinochimæra as well as on Chimæra and Callorhynchus. As with the ventral claspers, this is developed only when the animal is sexually mature. Its presence is therefore a distinctive character of all the living Chimæra-like fishes, and it is found in no other fishes. Mr. Garman's paper, though brief and not illustrated, is a most valuable addition to our knowledge of these fishes.

Under the head of "The Smallest Known Vertebrate," Dr. H. M. Smith gives in *Science* for Jan. 3, 1902, an account of a diminutive goby only fifteen millimeters long when adult, found in Lake Buki in southern Luzon, where, from its great numbers, it is an article of food of considerable importance. It is named *Mistichthys luzonius*. The genus is very close to the Japanese Eutæniichthys, also very diminutive, but it has larger and rougher scales than the latter.

In the *Bulletin of the Museum of Paris* for 1901, Dr. Pellegrin notes a collection of fishes obtained by M. Diguet in the Lake of Chapala and in Rio Lerma in Mexico. Most of the species have been already noted by Jordan and Snyder. One new species, *Xenendum multipunctatum*, is described from the pond called Agua Azul, near Guadalajara. I cannot agree with Dr. Pellegrin that *Ameiurus dugesi* of Lake Chapala is the same as *Ameiurus catus*, nor that the little *Gambusia infans* is the same as *G. affinis*.

Under the head of "Les Poissons Vénéneux," Dr. Jacques Pellegrin of the Museum at Paris publishes a valuable account of the fishes of which the flesh is known or suspected to be poisonous. It appears that in Tetraodon, Spheroides, Tropidichthys, Balistes, Monacanthus, and other genera — mostly globefishes, filefishes, and

trigger fishes — a poisonous alkaloid is developed which causes a very dangerous disease known in Cuba as ciguatera. This poison attacks the nervous system, and through it other organs, often producing death. Similar alkaloids of less virulence exist in sharks and some other fishes. Dr. Pellegrin regards it as a kind of device for the preservation of the species by the destruction of its enemies with the death of the individual. The virulence of the poison is less in fresh waters and grows less away from the tropics.

Similar effects are sometimes produced by the flesh of species otherwise innocuous which have been themselves poisoned by poisonous mollusks, polyps, or fish.

Illness caused by decayed fish flesh or by undigested fish has no relation to ciguatera. This Pellegrin calls "ichthyosisme," and it may be produced by various species under conditions adverse to assimilation.

In a monthly publication called *Japan and America*, for January, 1902, Dr. Jordan gives an account of the Salmonidæ of Japan, this paper being an epitome of one sent to Japan for publication. The valid species known in Japanese waters are the Sake (*Oncorhynchus keta*), the Ginmasu (*Oncorhynchus kisutch*), the Yesomasu (*Oncorhynchus masou* or *O. yessoënsis*, accidentally omitted in this paper), the Benimasu (*Oncorhynchus nerka*), the Yamabe or Kawamasu (*Salmo perryi*), the Ito (*Hucho blackistoni*), the Iwana (*Salvelinus pluvius*), the Malma (*Salvelinus malma*), the Amemasu (*Salvelinus kundscha*), and the famous Ayu, one of the finest food fishes in all the world (*Plecoglossus altivelis*). This dwarf salmon of the rivers should by all means be introduced into the clear streams of Maine, Quebec, and California. Few finer food fishes exist anywhere.

D. S. J.

Vascular System of Bdellostoma dombeyi. — C. M. Jackson[1] has made the vascular system of *Bdellostoma dombeyi* the subject of investigation. The author emphasizes the interest and importance attaching to the Cyclostomata owing to their being the lowest of the Craniata and possessing many structural features which must be regarded as ancestral. The blood-vascular system is described in detail, and certain points concerning its comparative anatomy are discussed.

The heart is a simple tubular organ, situated in a pericardial chamber which retains free communication with the peritoneal

[1] Jackson, C. M. An Investigation of the Vascular System of Bdellostoma dombeyi, *Journ. of the Cin. Soc. of Nat. Hist.*, vol. xx, No. 1, pp. 13–48. 3 pls.

cavity. There may be as many as fourteen pairs of functional branchial vessels, all the efferent branchial arteries on each side being connected by a longitudinal commissural vessel which continues forward as the common carotid of that side. The dorsal aorta extends forward into the head region. An inferior jugular vein is present, and there is a persistent subintestinal vein which does not join the portal system. These characters are among those which the author regards as primitive. There is a portal heart whose walls contain distinctly striated muscle fibers. The contractility of the portal heart is included among the primitive characters.

The following features the author considers to have been secondarily acquired. The venous system is asymmetrical. The branchial vessels distribute "to gill slits instead of gill arches." The portal system receives blood from the anterior body region. The caudal vein connects with the posterior cardinals. The portal heart has well-developed valves. H. W. R.

On Hair in the Equidæ. — F. H. A. Marshall[1] discusses the hair of Equidæ with special reference to peculiarities which, he believes, are of taxonomic importance. The chief characters which he finds to be of specific value are the shape and size, the extent of development of the medulla, the relative thickness of cortex and medulla, and the distribution and arrangement of pigment in the cortex. The cuticle exhibits only slight modifications in the several members of the group.

Much greater variability in the character of the hairs was found in *Equus caballus* than in the zebras. The hairs of zebra-horse hybrids show surprisingly little variation, even though the dams were of various breeds. The hybrid hairs resemble closely those of the zebra sire.

No evidence was found, so far as hair was concerned, in support of the telegony hypothesis. H. W. R.

Notes. — Wesley R. Coe describes the nemerteans collected by the United States Fish Commission steamer *Fish Hawk*, at Porto Rico, in the summer of 1899 (*Bulletin United States Fish Commission*, 1900, Vol. II, pp. 223–229). Eight species are represented among the very few individuals collected. At least three of the species are new. The collections of Professor Verrill, at Bermuda, and Ehrhardt, at Barbados, exhibit the same marked scarcity of nemerteans.

[1] *Proc. Royal Soc. Edinburgh*, vol. xxiii, pp. 375–390. 6 pls.

An isopod parasitic on the small hermit crabs found in the vicinity of Woods Hole is described by Millett T. Thompson (*Bulletin United States Fish Commission*, 1901, pp. 53–56, Pls. IX, X). The female parasite is found on the abdomen of the host, the comparatively small male being attached to the marsupium of the female. The isopod, probably representing a new genus allied to *Phryxus resupinatus* Müller, has been named *Stegophryxus hyptius*, the generic name being given in reference to the covering of the female, as it lies upon the host, by its marsupium.

Prof. Carl H. Eigenmann reports on his investigations into the history of the young squeteague of Buzzards Bay and Narragansett Bay (*Bulletin United States Fish Commission*, 1901, pp. 45–51). The young fish are pelagic in habit, subsisting entirely upon shrimp and smaller fish. The report considers further the distribution of the young squeteague, their rate of growth, and the changes accompanying growth, in body proportions and coloration.

Captain Tuttle of the revenue cutter *Bear* has presented to the Museum of Stanford University a pair of native boots which he brought back from a recent visit to the north, and which were made by a native on St. Lawrence Island in the Bering Sea from the skin of a half-grown bull fur seal, taken in the winter of 1900 in the ice adjacent to the island. St. Lawrence Island is 500 miles to the northward of the Pribilof Islands, and it is interesting to note that this is the first time the fur seal has been taken at any considerable distance north of the Pribilof group.

BOTANY.

De Bary's Bacteria. — The wisdom of a third edition of de Bary's *Vorlesungen über Bakterien*[1] so long after the death of its author may well be questioned. New discoveries on every hand have revolutionized old views, and to properly revise such a work would require it to be doubled in size and practically rewritten. This Dr. Migula has carefully refrained from doing. The title-page reads, "Dritte Auflage durchgesehen und teilweise neu bearbeitet von W. Migula," and in the preface apologies are offered for lack

[1] De Bary, A. *Vorlesungen über Bakterien.* Leipzig, Wilhelm Engelmann, 1900.

of thoroughness on the ground of respect for the memory of the author and for fear of disturbing the form or framework of the book. Changes have been made only "wo sich eine absolut zwingende Notwendigkeit ergab." De Bary, who loved thoroughness so well, would never himself have consented to such a thing. It is safe to say that the book will not please either the reviser or the readers. It is at least questionable whether it is ever wise to revise a book after an author's death, especially when very extensive changes will be necessary to bring it up to date, and in this case it is quite certain that Dr. Migula would have done much better to have written an altogether new book. The first edition of de Bary's *Vorlesungen über Bakterien*, published in 1885, contained 18 woodcuts and 146 pages of text. The new edition contains 41 figures and 186 pages of text. Three new chapters are added dealing with sulphur bacteria, nitrogen bacteria, and the question of immunity, toxins, antitoxins, toxalbumins, etc. The book is about the size of Fischer's *Vorlesungen* and will find a place beside it on the library shelf. It compares very favorably with Fischer's book, but, as in the case of the latter work, the least well-made part of the compilation is that relating to plant diseases. Four diseases only are noticed, and no contribution more modern than Kramer's wet rot of the potato, published in 1892, finds mention. In case of Wakker's hyacinth disease, de Bary's statement that "successful infections and an exact following of the life history of the bacterium are still wanting" is repeated. Under "pear blight," the long exploded statement that the organism produces carbon dioxide, hydrogen, and butyric acid is once more repeated. Under Kramer's "wet rot of the potato," it is thought to be safe to hint that there may possibly be other bacteria capable of producing similar phenomena. Of general statements, the following sufficiently indicate the value of this résumé: "The firm cell membrane of the plant cell is an almost insurmountable obstacle to the bacteria, especially as the very great majority of the bacteria are not able to attack cellulose. It is true that in recent years especially there have been described very many so-called "bacterioses," that is, diseases in plants caused by bacteria, but only a few will stand searching criticism. . . . In the great majority, bacteria are certainly not the cause. . . . Considering the uncertainty and inadmissibility of most of the accounts relative to bacterioses, there is no necessity of inquiring further about diseases which presumably will sooner or later be stricken out of the list of the bacterioses."

All of which means that to be a safe guide a man must actually have done something in the particular field which he undertakes to summarize. The book is well made and attractive in appearance.

E. F. S.

A New Elementary Text-Book. — A clear indication of the broadened scope of botanical instruction is afforded by the discarding of class books which only a decade or two ago were sufficient for the purposes of the ordinary teacher. The books that have replaced them are not only very different from their predecessors but from one another. Some are questionably the equals in any respect of those that are dropping out; others, though they have the merit of giving a broadened view of the subject, overshoot the classes they are intended for; still others are as one-sided on a new phase of the science as the older ones were on another.

As long as there is individuality in teachers, universal satisfaction is hardly to be expected from any text-book, and as questions of temperance and cruelty have not yet intruded themselves into the botany of secondary schools, it is probable that individuality in its teachers may long resist the tendency to mechanical uniformity to which many forces contribute with considerable persistency. With any book, however much the teacher may desire to avoid giving the impression that all desirable knowledge is contained between its covers, it is difficult to prevent many pupils from at least tacitly holding this opinion, and good as many of the recent books are, it is to be feared that their use is causing some of the wholesome everyday knowledge of one's dooryard plants of a generation ago to be replaced by a broader and doubtless more scientific, but unfortunately less practically tangible knowledge of vegetation in the abstract.

To meet the undoubted need of a more comprehensive work than Dr. Gray's *Lessons* without losing the advantage of its rational point of view, excellent spirit, and good handling, Mr. Leavitt, at the request of the botanical department of Harvard University, has based on it a little book[1] which appears admirably adapted to the class room, and which, by the introduction of a series of well-devised and simple exercises, makes possible that most desirable of evolutions, — the conversion of the recitation room into a laboratory.

T.

[1] Leavitt, R. G. *Outlines of Botany for the High School Laboratory and Class-Room.* Based on Gray's *Lessons in Botany*. American Book Company. 272 pp., 383 figs.

Notes. — Mr. Gandoger has turned his discriminating eye on the North American representatives of Astragalus and Oxytropis, and in the number of the *Bulletin de la Société Botanique de France* of January 5 he adds a considerable number to their named species, varieties, and forms.

A Rhododendron related to *R. punctatum*, and from the Savannah River, Ga., is described under the name *R. cuthbertii*, by Dr. Small in *Torreya* for January.

In *Torreya* for January Mr. Howe extends the range of *Arceuthobium pusillum* to Nova Scotia and Newfoundland.

Three palms (*Ptychosperma elegans*, *Archontophœnix cunninghami*, and *A. Alexandræ*), commonly cultivated under the name *Seaforthia elegans*, are disentangled in the *Gardeners' Chronicle* of January 11, by Dammer, who illustrates the first and last named by reproductions of photographs taken in the Buitenzorg garden.

The species of Porphyra of the Pacific coast of North America are revised by Hus in Vol. II, No. 6, of the botanical section of *Proceedings of the California Academy of Sciences*, issued January 4.

Professor Peck's "Report of the State Botanist" for 1900, separately printed from the 54th *Report of the New York State Museum*, contains plates illustrating a large number of edible agarics.

Bulletin No. 3 of the Lloyd Library is the first number of a mycological series, and deals with the genera of Gastromycetes. Mr. C. G. Lloyd is the author. Forty-nine figures, mostly half tones, are used in illustration.

Miss Vail gives a readable history of Van der Donck and his seventeenth century New Amsterdam garden, in the *Journal of the New York Botanical Garden* for December.

In *Rhodora* for December, Miss Day concludes her annotated list of the herbaria of New England.

A short article on Lapham, whose herbarium is preserved at the University of Wisconsin, is contributed by his daughter to *The Wisconsin Archæologist* for January.

The *Journal of Botany* for December contains a good portrait of J. G. Baker.

In a neatly gotten-up but rather crudely illustrated booklet published by William Briggs of Toronto, and entitled *Sylvan Ontario*, Principal Muldrew of the Gravenhurst high school gives leaf keys to

the recognized trees and shrubs of his district. It is pleasing to read that the high school possesses an arboretum in which practically all of the species are cultivated.

The relation of forests to snow is discussed by Carpenter in *Bulletin No. 55 of the Colorado Experiment Station*, illustrated by a series of photograms from excellent negatives.

In paper, presswork, and general appearance the third annual report of the New York State College of Forestry, recently distributed, is more like a product of the British colonies than of the United States.

The value of growth rings in the so-called exogenous trunk, as an index of age, is considered by Roger in the *Revue Horticole* of January 1.

The distribution in Iowa of twenty native forest trees is discussed by Professor Bessey in *The Forester* for December.

The big trees of California are the subject of a well-illustrated article by R. T. Fisher in *The World's Work* for February, which also contains illustrated articles on the cultivation of tobacco under cloth in Connecticut and the growing of olives in California.

What the cedar of Lebanon may become in cultivation is shown by photograms in the *Gardeners' Chronicle* for January 4.

PETROGRAPHY.

Tillman's "Text-Book of Important Minerals and Rocks,"[1] is an attempt to present to the student a brief account of the characteristics of the common minerals and rocks. The plan of the book is good. It discusses the elements of geometrical crystallography in 24 pages, in which only the most fundamental forms of the six systems are described. The physical and chemical properties of minerals are discussed in the next 5 pages. Then follow 65 pages devoted to the description of about seventy-five of the commonest mineral species, and about 40 pages in which the descriptive material is embodied in tabular form. The final 22 pages treat of the commonest rocks.

[1] Tillman, S. E. *A Text-book of Important Minerals and Rocks.* With tables for the determination of minerals. New York, John Wiley & Sons, 1900. 186 pp., 35 figs.

For an elementary treatise the book contains enough matter. The author unquestionably did well when he decided to limit his descriptions to seventy-five species and make them fairly full rather than to attempt to discuss a greater number and devote only a few lines to each. There is nothing to criticise unfavorably in the chapters on crystallography and on the physical and chemical properties of minerals. They are extremely brief, to be sure, but they are well arranged. Their topics are well chosen, and the statements in them are accurate. The tables are likewise good. They contain no peculiar features that need elucidation.

In the descriptive portion of the volume there is quite a little loose writing, which is especially to be condemned in a beginner's book. The order in which the minerals are taken up is that which seems to appeal to most writers of elementary treatises. It is not scientific, but it possesses the advantage of impressing on the student the economic importance of the different compounds. The important metals and their ores and compounds, other than the silicates, are treated together. Then come the silicates. The grouping of the latter follows no general scheme. The order in which they are discussed "is mainly intended to emphasize and fix in mind their relationships and importance as rock-forming minerals." There are some errors in this portion of the book and many irregularities in the headings of the paragraphs. Many chemical formulas are omitted where they might serve a useful purpose. This is particularly true in the case of the silicates, for which no composition formulas are given. In a few cases not even is the composition referred to. There is an unfortunate spacing of paragraphs, that undoubtedly will cause confusion. After the heading "Feldspathoid Group" there is no spacing to indicate that this group does not include all the minerals following it to the end of the book.

These faults, and others like them which might be mentioned, may seem very slight and trivial. As a matter of fact, however, they are serious in a text-book for beginners, since, though they may not teach error, they certainly lead to misconceptions on the part of the students. They may easily be corrected in a revision ; and a revised edition, in which these corrections are made, would prove a very satisfactory text-book.

The second part of the volume is devoted to the common rocks. It is so brief as to be of little value. The omission of a number of the rock names mentioned would not have injured the book in the least. Peperino, talus, detritus, eurite, ophiolite, itacolumite, and

hydromica schists occupy the student's attention when he might better be learning something more about gabbro than that it is a "coarse diabase." The use of "syenitic" as an adjective synonymous with hornblendic is no longer to be tolerated in an elementary text-book, in spite of "its wide popular use in this sense in this country." This wrong usage of the word will never be done away with so long as it is taught in the text-books.

There are some inconsistencies in the classification, but they are not mischievous. There are also several statements concerning the composition and origin of a few rocks that will not bear close scrutiny.

Since there are no very elementary text-books dealing with rocks published in English, the present volume has a place to fill. It is a welcome aspirant for the honor of initiating beginners into rock study. It would have been more welcome, however, had it left some of its useless baggage behind. We hope Professor Tillman will revise the entire book, as there are many good points about it. In its scope it certainly "fills a want." The volume contains 38 crystallographic figures but otherwise is not illustrated. W. S. B.

The Differentiation at Magnet Cove. — Washington[1] has made new analyses of some of the Magnet Cove plutonic rocks that lead to interesting conclusions. He finds that many of the earlier analyses are lacking in accuracy. The new analyses result in a change in the former classification of some of the rocks and seem to render necessary a few new rock names. From the analyses he calculates the composition of some of the important types to be as in the table on opposite page.

The covite was formerly regarded as a shonkinite. Its qualitative composition is close to that of theralite. The latter, however, contains a large quantity of nepheline, while the former contains a comparatively small quantity. On the other hand, shonkinite is melanocratic, while covite is mesocratic (that is, it contains about equal quantities of dark and light constituents). According to Rosenbusch's definition covite is a typical shonkinite, but Rosenbusch's shonkinite is an entirely different type from the original shonkinite of Pirsson.

The arkite has been wrongfully designated a syenite. It is most nearly allied to missourite, but it differs from this rock in the same way that covite differs from shonkinite, *i.e.*, it is a leucocratic

[1] *Journ. of Geol.*, vol ix (1901), p. 607.

aggregate of leucite and nepheline, with subordinate dark components. The author defines it as a "holocrystalline, porphyritic, leucocratic combination of leucite (or pseudo-leucite) and nephelite, with pyroxene and garnet." The jacupirangites of Brazil vary from rocks rich in nepheline (true ijolites), through rocks composed predominantly of pyroxene with small and varying amounts of magnetite and nepheline, to types rich in magnetite and with little or no nepheline. The Magnet Cove rock corresponds to the intermediate of the Brazilian types.

	I.	II.	III.	IV.	V.	VI.	VII.
Orthoclase	35.1	28.6	51.8	29.3	3.9		
Albite	39.8	39.0		22.8			
Leucite					36.9		
Nepheline	3.1	6.2	20.3	9.0	25.5	38.7	4.0
Cancrinite			13.1				
Sodalite	1.2						
Nosean		1.2					
Ægirite	5.1	6.9	5.7	4.5	8.4	4.6	
Hornblende }				18.8	Augite	6.9	15.0
Diopside }	11.0		8.6	9.0	10.8	31.3	64.0
Biotite }		7.9					5.0
Apatite	.5			1.0		3.0	
Sphene		2.7	.5	3.1			
Magnetite				2.5			8.7
Extra Al_2O_3	4.2		Garnet		14.5	15.3	

I. Pulaskite, from Fourche Mt., Arkansas.
II. Pulaskite (foyaite), Braddock's Quarry, Fourche Mt.
III. Foyaite, Diamond Jo Quarry, Magnet Cove.
IV. Covite, near schoolhouse, Magnet Cove.
V. Arkite (leucite-porphyry), near Diamond Jo Quarry.
VI. Ijolite, near Dr. Thornton's, Magnet Cove.
VII. Jacupirangite, near Baptist church, Magnet Cove.

In a second[1] article the author discusses the chemical relationships of the rocks with great fullness. He represents the variations in their composition by diagrams and with the aid of these calculates the composition of the magma which gave them birth by methods that are somewhat novel. The peculiar differentiation of the mass is thought to be due to its small size. The process was probably a "sort of fractional crystallization, the magma being regarded as a solution, so that, in accordance with the laws of cooling solutions, the solvent (the portion in excess) crystallizes out first around the borders on

[1] *Journ. of Geol.*, vol. ix (1901), p. 645.

cooling of the mass." The original body of magma was leucocratic, so that the alumina and alkalies with silica enough for the formation of feldspar and feldspathoids, crystallized first, and hence in the periphery of the mass.

Densities of Liquid and Solid Rock Magmas. — In view of the fact that a recently proposed theory of volcanic action accounts for the eruption of lava as the consequence of the expansion of liquid magma in its passage to the solid state, a paper by Doelter,[1] in which this author discusses the densities of liquid and solid magmas, becomes of great interest. By means of a series of experiments, in the course of which fragments of known density were allowed to float or sink in molten magmas, Doelter obtained a series of results which are embodied in the following table, the figures indicating specific gravities:

	Natural Substance.	Molten.	Glassy.	Crystalline.
Melanite	3.75	3.55–3.6	3.55–3.6	3.65–3.7
Augite	3.3	2.92	2.92–2.95	3.2 –3.25
Limburgite	2.83	2.55–2.57	2.55–2.57	2.75–2.78
Lava (Ætna)	2.83	2.58–2.74	2.71–2.75	2.81–2.83
Lava (Vesuvius)	2.84	2.68–2.74	2.69–2.75	2.77–2.81
Nephelinite	2.74	2.70–2.75	2.686	2.72–2.75
Leucitite	2.83	2.60–2.68	2.68–2.72	2.75–2.79

The Laccolite of Shefford Mountain.[2] — Shefford Mountain is the easternmost of the series of nine hills of igneous material that rise above the St. Lawrence valley in the neighborhood of Montreal. It is thought by Dresser to be an old laccolite in Lower Cambrian and Trenton sediments. Its material consists of essexite, nordmarkite, and pulaskite, the first two of which possess almost the typical character of these rocks. Associated with these are dark-colored dykes of a camptonitic type, and others of a theralitic type, and light-colored ones of trachyte and bostonite. The latter are the younger. All the rocks are thought to be differentiated products of a single magma. The primary magma, according to this view, had nearly the composition of pulaskite. Excluding the dykes the first differentiate was the basic essexite, the second was the acid nordmarkite, and the third the intermediate pulaskite. The analyses of the essexite (I),

[1] *Neues Jahrb. of Univ.*, etc., Bd. ii (1901), p. 141.
[2] *Amer. Geologist*, vol. xxvii (Oct., 1901), p. 205.

the nordmarkite (II), the pulaskite (III), and the mean between the first two (IV) follow:

SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	CaO	BaO	MgO	K_2O	Na_2O	P_2O_5	CO_2	SO_3	Cl	H_2O	Total
53.15	1.52	17.64	3.10	4.65	.46	5.66	.13	2.94	3.10	5.00	.65	.39	.28	.07	1.10	= 99.86
65.43	.16	16.96	1.55	1.53	.40	1.36		.22	5.36	5.95	.02		.06	.04	.82	= 99.84
59.96	.66	19.12	1.85	1.73	.49	2.24	.12	.65	4.91	6.98	.14		.08	.14	1.10	= 100.17
59.29	.84	17.30	2.32	3.09	.43	3.51	.07	1.58	4.23	5.47	.34	.20	.17	.06	.96	= 99.85

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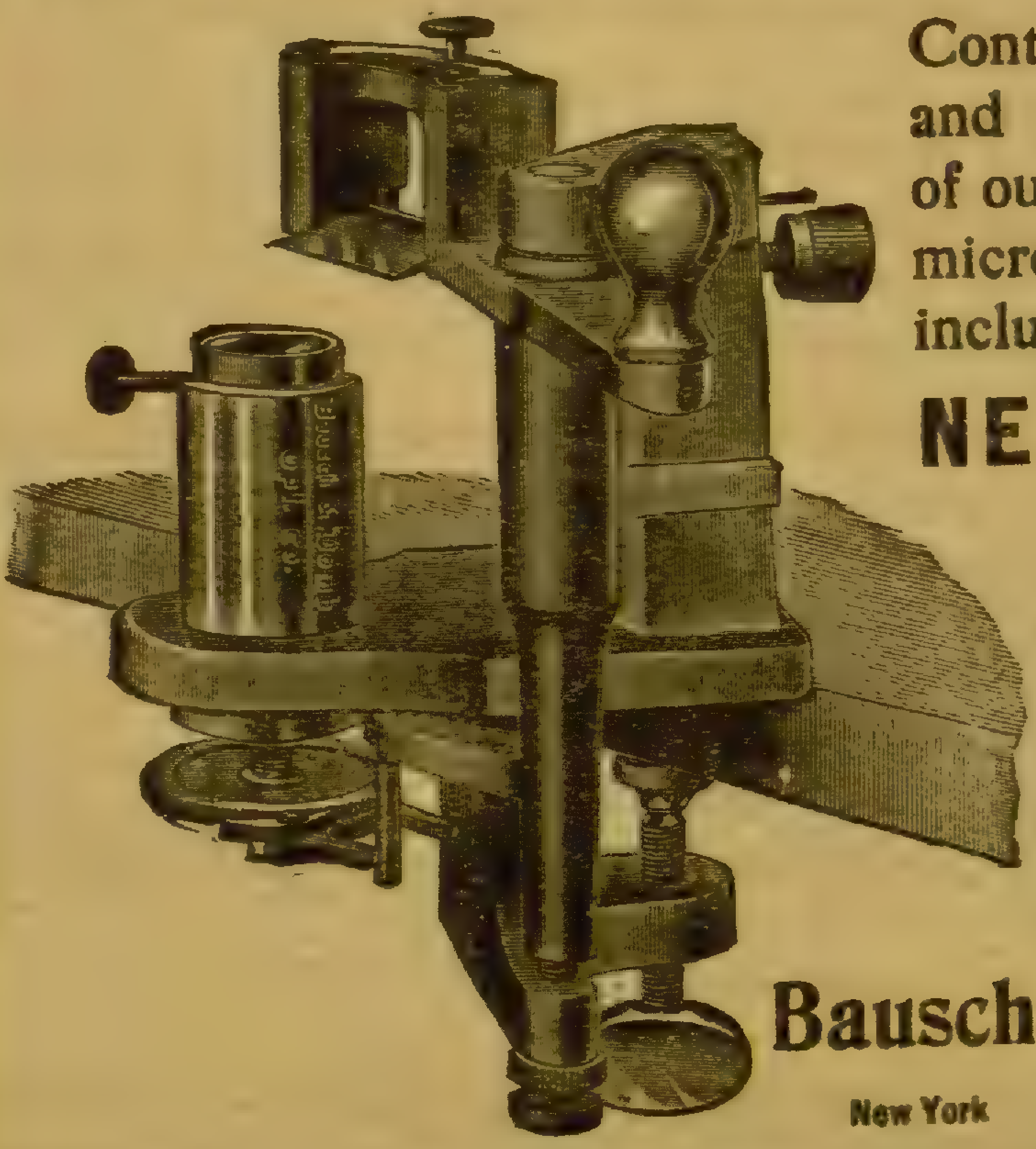

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THE AMERICAN NATURALIST

A MONTHLY JOURNAL
DEVOTED TO THE NATURAL SCIENCES
IN THEIR WIDEST SENSE

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THE

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THE LAW OF ADAPTIVE RADIATION.

HENRY FAIRFIELD OSBORN.

One of the essential features of divergent evolution as conceived in the branching system successively developed by Lamarck, Darwin, Huxley, and Cope has been termed by the writer "adaptive radiation." This term seems to express most clearly the idea of differentiation of habit in several directions from a primitive type, as shown in the accompanying diagrams. The law is a familiar one; it results in the formation of analogous radii in different groups of animals. The first comprehensive illustration of the law known to the writer is that under the headings "Homologous Groups" and "Heterology," in Cope's paper of 1868 on the "Origin of Genera," reprinted in the *Origin of the Fittest* (pp. 95–106). This brilliant essay is marred only by great confusion in the use of terms; but the parallelisms in unrelated groups of amphibians and of mammals such as marsupials and placentals, as first observed by Owen, are clearly brought out.

In the present paper citations from earlier essays of my own may be given bearing upon *general adaptive radiation* and the independent production of analogous radii under the convergent

principles of homoplasy, parallelism, and convergence, which, as shown in the last number of the *Naturalist*, are by no means synonymous terms or identical processes. The altogether similar law of *local adaptive radiation* or incipient divergence on a smaller scale in a single locality may now be more clearly developed.

This idea of radiation becomes a means of interpretation, and a way of imagining the relations of extinct and living faunæ. As perceived by Cope, it applies both on a small and on a vast scale.

I. General Radiation.

In the "Rise of the Mammalia" ('93, pp. 30–33) the ancient Mesozoic (Meseutheria) and modern Cenozoic (Ceneutheria) differentiation of the placentals (Eutheria) was spoken of as follows:

> The Puerco is essentially an archaic fauna, and is to be regarded as the climax of the first period of placental differentiation, a culmination of the first attempts of nature to establish insectivorous, carnivorous, and herbivorous groups. These attempts began in the Cretaceous, and some of the types thus produced died out in the Puerco, some in the Wasatch and Bridger; only a few flesh-eaters survive to the Miocene. It is most important to grasp clearly the idea of this *functional radiation* in all directions of this old Puerco fauna, resulting in forms like the modern insectivores, rodents, bears, dogs and cats, monkeys, sloths, bunodont and selenodont ungulates, and lophodont ungulates. This was an independent radiation of placentals, like the Australian radiation of marsupials.
>
> Some of the least specialized spurs of this radiation appear to have survived and become the centers of the second or mid-Tertiary radiation, from which our modern fauna has evolved. Yet we have not in a single case succeeded in tracing the direct connection.[1] To sum up, we find on the North American continent evidence of the rise and decline and disappearance of monotremes and marsupials, and two great periods of placental radiation, the *ancient radiation* beginning in the Mesozoic, reaching a climax in the Puerco and unknown post-Puerco, and sending its spurs into the higher Tertiary, and the *modern radiation* reaching its climax in the Miocene, and sending down to us our existing types.

[1] This statement has been modified by subsequent discovery.

In the "Origin of the Mammals" ('**99**, p. 92) the idea was developed as follows:

To guide our speculation in the unknown pre-Tertiary period, we may gather certain positive principles from the known evolution of the Tertiary Mammalia. First, we know that *adaptive radiation*, characteristic of all vertebrates, and beautifully illustrated among Reptilia, is in a very high degree distinctive of Mammalia, because of their superior plasticity.

The *focal-types*, or most primitive forms of the radiations, I–IV, *were certainly small, terrestrial, clawed, insectivorous or omnivorous forms.* It is noteworthy that in the evolution of each radiation, so far as we know at present, land types and organs are invariably primitive, and water types and organs are secondary, exactly as we find among the Reptilia. In fact, we have not found a single instance in which a mammal or reptile series is known to be transformed from a water into a land type: it is always the reverse. There is certainly no evidence for a cetoid (Albrecht) stem of the Mammals. Again, it is obvious that neither carnivorous nor herbivorous types with highly specialized or reduced teeth and feet can be so central as insectivorous and omnivorous types. In fact, the Insectivores among Placentals, and Opossums among Marsupials, are the only animals which have preserved the dental prototype close to that of the Promammal.

The radiations spoken of in this essay were:

I. *Marsupial Radiation of Australia* (Meteutheria).
II. *Tertiary Placental Radiation of the Northern Hemisphere*, i.e., *North America, Asia, and Europe* (Ceneutheria).
III. *Tertiary Placental Radiation of South America* (Ceneutheria).
IV. *Cretaceous Placental Radiation of North America* (Meseutheria).
V. *Jurassic Radiation of Placentals and Marsupials.*

In a subsequent paper, "The Geological and Faunal Relations of Europe and America during the Tertiary Period, and the Theory of the Successive Invasions of an African Fauna" ('**00**), the subject was further developed as follows:

Now it is a well-known principle of zoölogical evolution that an isolated region, if large and sufficiently varied in its topography, soil, climate, and vegetation, will give rise to a diversified fauna according to the law of adaptive radiation from primitive and central types. Branches will spring off in all directions to take advantage of every possible opportunity of securing food. The modifications which animals undergo in this adaptive radiation are largely of mechanical nature, they are limited in number

and kind by hereditary, stirp, or germinal influences, and thus result in the independent evolution of similar types in widely separated regions under the *law of parallelism or homoplasy*.[1]

II. Adaptive Radiation of Orders and Families as bearing on Geographical Distribution.

This law causes the independent origin not only of similar genera but of similar families and even of similar orders. Nature thus repeats herself on a vast scale, but the similarity is never complete or exact. When migrations are favored by over-population or geographical changes, a new and severe test of fitness arises by the mingling and competition of the parallel types.

Under the operation of these laws a most interesting generalization or hypothesis can be made as to the three [zoölogical] realms: geographical

FIG. 1. — Orders of mammals placed in their hypothetical chief centers of adaptive radiation during the Tertiary period. (From Osborn.)

isolation has been so continuous and prolonged that great orders of mammals have been evolved . . . in each. Thus *Arctogæa*, containing the broadest and most highly diversified land area, appears hypothetically as the center in which fourteen primitive and specialized orders radiated from each other. In the southern portion of *Neogæa* at least four orders sprang from primitive members of the above orders, and the Hystricomorph rodents enjoyed their chief radiation. In *Notogæa* two orders were cut off by the sea; one of them a rapidly declining type, the Monotremes, the other, the Marsupials, enjoying a very highly diversified radiation. This

[1] At this time the distinction between homoplasy and parallelism was not appreciated by the writer.

hypothesis is expressed in Fig. III [Fig. 1]. The other orders of mammals, the Sirenia (probably a branch of the hoofed tribe), took the rivers and coasts of America, Europe, and probably Africa as their radiating center, while the Cetacea occupied the fourth or oceanic realm.

We mean to express by this hypothesis that REALMS [Fig. 2] *were the main centers of adaptive radiation of orders of mammals*, but by no

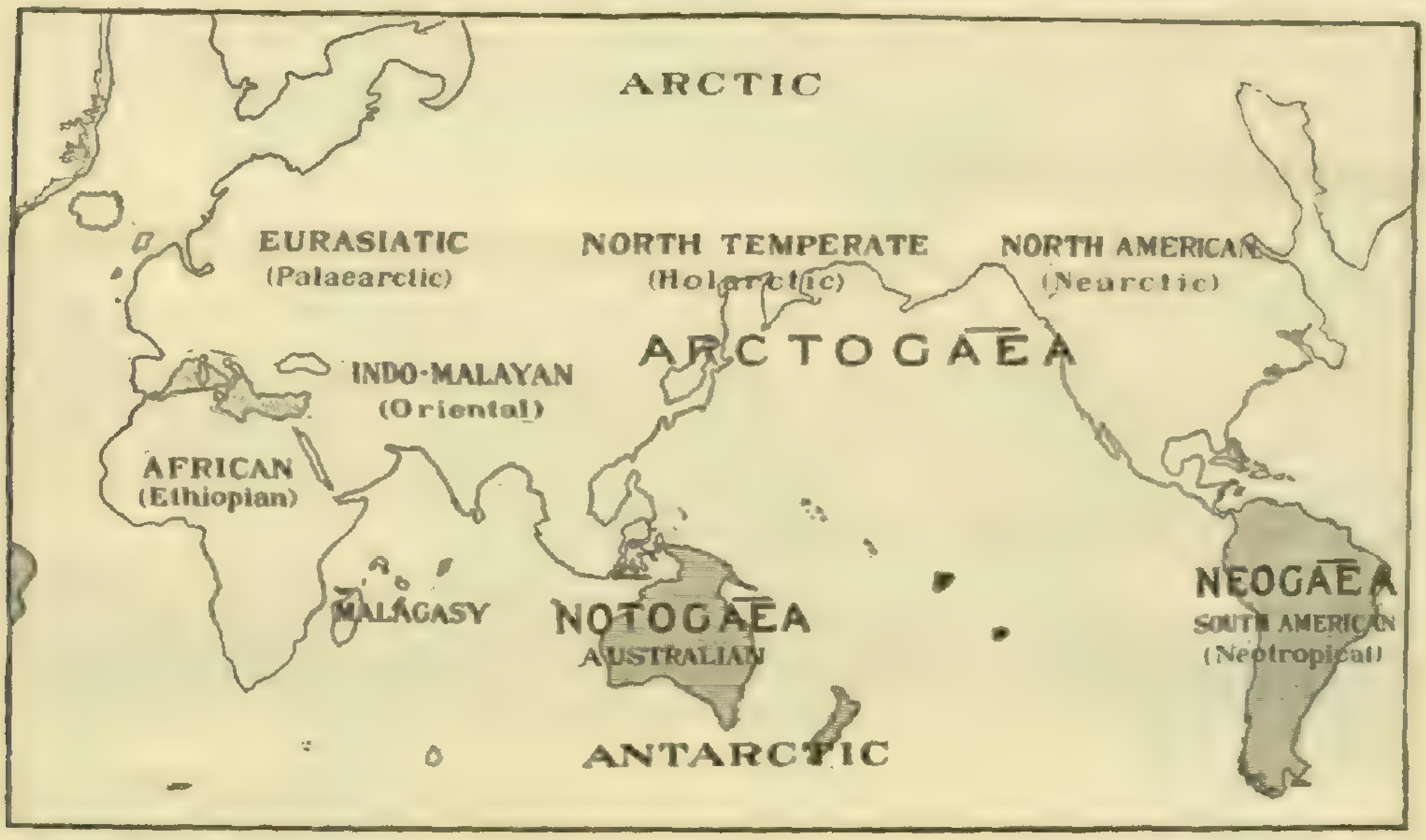

FIG. 2. — Division of the world into three realms and nine main geographical regions. The continental platform is raised to the 200 meter line showing the main Tertiary land connections. (From Osborn.)

means the exclusive areas of distribution, for during the periods of land contact certain members of these orders found their way into adjacent realms. Each realm, therefore, contains its pure autochthonous types and its migrant or derived types. REGIONS, on the other hand, may be distinguished from realms as geographical and zoölogical areas, which have been isolated from each other for shorter periods, either by climatic barriers, as in the case of the Arctic or circumpolar region, or by great physical barriers, such as masses of water and of desert sands. In certain cases these regions, such as Africa, appear to have been so large, distinct and isolated, as to have become important centers of the radiation of certain *orders* of mammals and almost attain the rank of realms, but regions in general are chiefly and permanently distinguished by the *adaptive radiation of families of mammals*.

In this paper Africa was treated hypothetically as a great center of independent evolution and as the source of successive northward migrations of animals. This hypothesis has recently been confirmed by remarkable paleontological discoveries in northern Africa. This adds to the above list of five radiations a sixth, namely :

VI. *African Radiation of Placentals*, chiefly Proboscidea; Hyracoidea; the families Antelopidæ, Giraffidæ, Hippopotamidæ, etc.

FIG. 3.— Restoration of Antarctica, a hypothetical center of Tertiary adaptive radiation, by elevation to the 3040 sounding line, showing old continental lines. (From Osborn.)

III. THE LAW OF LOCAL ADAPTIVE RADIATION AS EXHIBITED IN RELATED CONTEMPORANEOUS TYPES.

As seen in operation among the ungulates the competition and range for food originates the lengthening of limb from slow-footed into cursorial types, and the lengthening of teeth from short-crowned (brachyodont) into long-crowned (hypsodont) types, and frequently the lengthening of skull from brachycephalic into dolichocephalic types (Osborn, '02a).

The especial application to paleontology to be noted here is that as these types may have lived together or in proximity and resorted to the same water courses for drink, their fossilized

remains are often found together. Yet if we examine analogous types living to-day, we see that they do not frequent exactly the same feeding ranges nor do they subsist upon exactly the same food; they thus do not compete. Good illustrations of this *local adaptive radiation* are seen in the distribution in Africa of the closely allied square-lipped *Rhinoceros simus* with hypsodont teeth, which lives upon grasses, and the more pointed-lipped *R. bicornis* with brachyodont teeth, which lives mainly upon shrubs. Both species belong to the same phylum of rhinoceroses. Among fossil types closely related to the above we observe similar cases, such as the coexistence in the lower Pleistocene of the hypsodont *R. antiquitatis* (woolly rhinoceros) and the brachyodont *R. hemitœchus.*

If carried farther than in the above instances, we may be justified in placing these *local adaptive radiations* in separate subfamilies, because in many cases they give rise to distinct and long-persistent collateral phyla.

Examples of this kind are numerous among the ancient Perissodactyla or ungulates related to the horses, tapirs, and rhinoceroses, as seen below.

	I. Stout-Footed, Heavy-Limbed Phylum.	II. Slender-Footed, Light-Limbed, Cursorial Phylum.
Families.	*Subfamilies.*	*Subfamilies.*
1. Palæotheriidæ	Palæotheriinæ *B.*[1] (Middle Eocene to Lower Oligocene)	Palaplotheriinæ (Middle Eocene to Lower Oligocene)
2. Titanotheriidæ	Palæosyopinæ *B.* (Middle Eocene to Upper Eocene)	Telmatototheriinæ *H.*[1] (Middle Eocene to Upper Eocene)
3. Hyracodontidæ	Hyrachyinæ *B.* (Middle to Upper Eocene)	Triplopodinæ *B.* (Middle to Upper Eocene)
4. Lophiodontidæ	Lophiodontinæ *B.* (Middle to Upper Eocene)	Helaletinæ *B.* (Eocene) Colodontinæ *B.* (Oligocene)

It will be observed at once that there is no inherent correlation between *brachyodontism* and *brachypody*, or *hypsodontism* and *dolichopody*, or elongation of the feet, as we might have anticipated, although hypsodontism is gradually developed in

[1] B. = brachyodont; H. = hypsodont.

most long-footed series because subsistence upon grasses is associated with such conditions of life as are afforded by extensive open plains, long ranges for food, and rapid flight from enemies. Again, as shown elsewhere, dolichocephaly and dolichopody, brachycephaly and brachypody are frequently but not invariably correlated. (See Osborn, '02a.)

The value of this law of *local adaptive radiation* is especially great as a means of interpretation of the frequent contemporaneous existence or association of more primitive (brachyodont) with more specialized (hypsodont) types. Among Tertiary machærodont cats it is seen in the contemporary long-limbed *Dinictis* and short-limbed *Hoplophoneus*. In fact, the association has been so often observed that if we find one phylum, we may almost anticipate or predict the discovery of the other.

The law is made more clear by referring to the above table and the following explanation of it: (1) As compared with the Palæotheriinæ, the Palaplotheriinæ are so long-footed that Huxley believed that they gave rise to the horse, and he actually placed *Paloplotherium minus* as the ancestor of the horse series. (2) The Telmatotheriinæ are large animals also distinguished by very long, slender limbs; they independently acquired horns, and the species *T. cornutum* was believed by Osborn to be ancestral to the titanotheres; but as a matter of fact, as shown by Earle and Hatcher, this horn is a pure case of parallelism, since the titanotheres probably sprang from the short-skulled and relatively stout species, *Palæosyops manteoceras*, a member of the Palæosyopinæ. (3) The Triplopodinæ present the most extreme instance of light-limbed development among the perissodactyl ungulates, since the limbs have the proportions of some of the most slender and swift-footed ruminant mammals, although these animals are found in the same beds with the correlated subfamily Hyrachyinæ. (4) Among the Lophiodontidæ, the Helaletinæ bring out with additional force the principle that this elongation of limb occurred at a very early geological period; because the first known member of this phylum appears way down in the Lower Eocene, Wasatch, or Suessonien beds, in the genus *Heptodon* Cope, a remarkably light-limbed form, and it runs right through,

so far as we know, into the Oligocene genus *Colodon*, the three-toed type with extraordinarily elongate digits. So far as we know, this light-limbed series is found both in America and Europe, while the heavy-limbed Lophiodontinæ are found only in Europe.

Since the above was written the titanotheres have been more carefully examined by the writer (Osborn, '02b), and, like the rhinoceroses, they are found to subdivide into four contemporaneous phyla distinguished chiefly by dolichocephaly and brachycephaly and by relatively long and short limbs, thus affording another conspicuous illustration of this *law of local adaptive radiation.*

IV. Radiation and Correlation of Structure.

In the careful consideration of adaptive radiation from certain stem types is to be found the true significance of Cuvier's *law of correlation* as modified by the — to him — unknown principle of evolution. Referring to the diagrams, Fig. 4, two important principles are brought out: First, practically all the adaptations known among mammals have arisen by combinations of divergence independently pursued in the limbs and teeth; for example, an herbivorous tooth type may combine with a terrestrial, arboreal, or volant limb type, according as the search for plant food is on the earth, in the trees, or in the air. Although every imaginable combination (*e.g.*, aquatic limbs, myrmecophagous dentition) cannot be realized, yet these combinations have been multiplied almost *ad infinitum* and constitute the fatal defect of Cuvier's law as he conceived it. As tested by a single case, the Eocene monkeys of the family Notharctidæ acquired teeth exactly homoplastic with those of Eocene horses, but the former were provided with arboreal, the latter with terrestrial, limb types. Second, correlation of limb and tooth structure in a given group is further conditioned by the particular combination and degree of specialization of limbs and teeth which the radiation originates with. For example, the primitive placentals combined tritubercular insectivorous teeth with a generalized or probably terrestrial

type of feet; the Australian marsupial radiation, on the other hand, began with a dental type similar to that of the placentals,

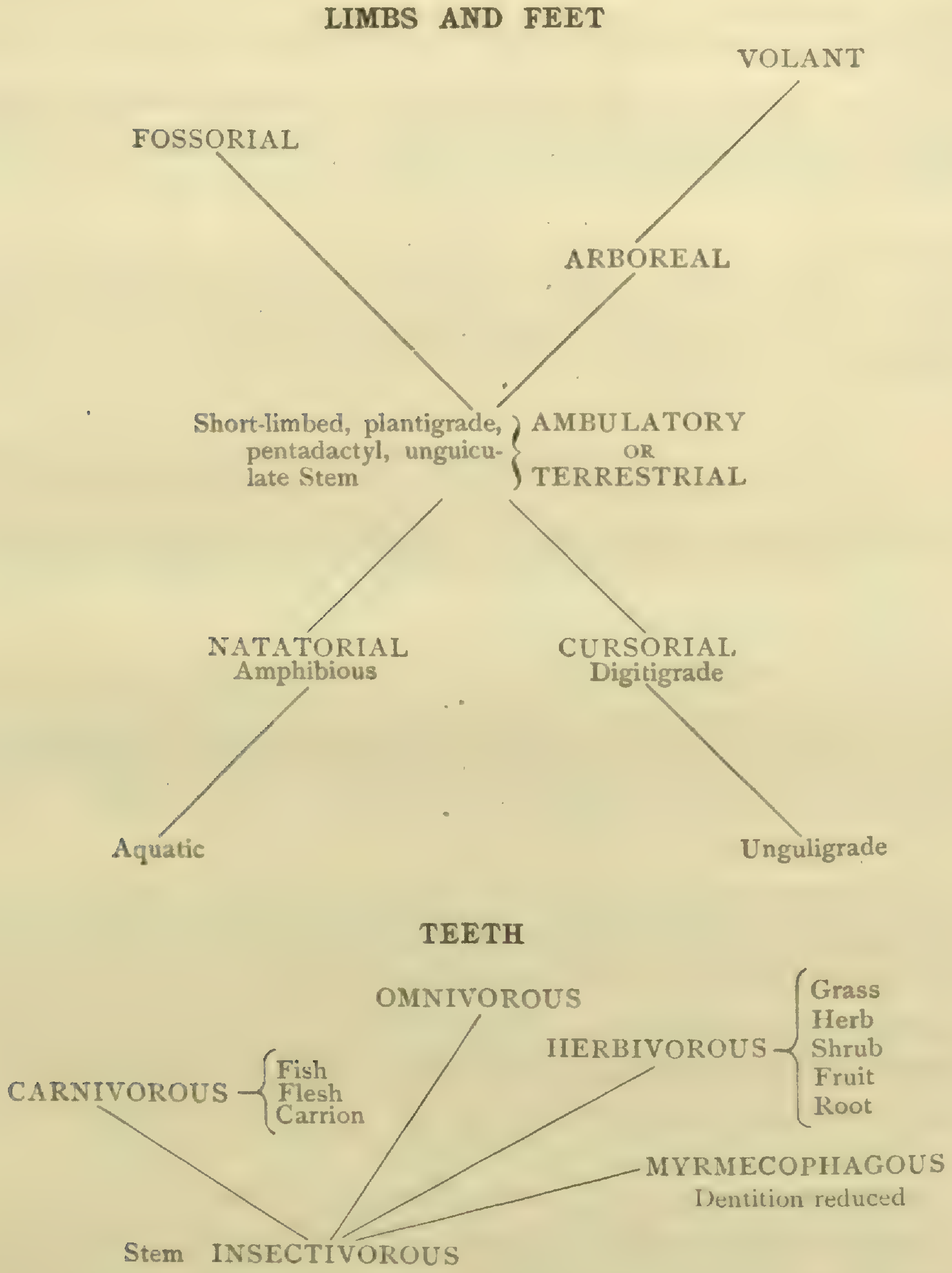

FIG. 4.—Main lines of adaptive radiation of (*a*) limbs and feet, (*b*) teeth among mammals.

but, as Dollo and Bensley have shown, the foot type was of highly specialized arboreal character.

These two fundamental exceptions make clear why it is impossible, as many writers have observed, to reconstruct an

entire animal from either a claw or a tooth. Thus, while the law of correlation is no less dominant than Cuvier supposed, only a vestige is left of the mode of archetypal operation of the law as he conceived it. It may be now restated as follows: Feet (correlated chiefly with limb and body structure) and teeth (correlated chiefly with skull and neck structure) diverge independently in adaptation respectively to securing and eating food under different conditions. Each evolves directly for its own mechanical functions or purposes, yet in such a manner that each subserves the other.

Correlation is therefore not morphological, as Cuvier supposed, but physiological, function always preceding structure. It becomes closest where teeth and feet combine in the same function as in the prehensile canines and claws of the Felidæ, and most diverse where the functions are most diverse, as in the teeth and paddles of the Pinnipedia.

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NEW AND LITTLE-KNOWN GUESTS OF THE TEXAN LEGIONARY ANTS.[1]

CHARLES THOMAS BRUES.

The species included in the present paper are all Ecitophiles which have been collected in the vicinity of Austin, Texas, by Dr. Wm. M. Wheeler, Mr. A. L. Melander, and the author, during the past two winters. The three species of Eciton (*E. schmitti* Em., *E. opacithorax* Em., and *E. cæcum* Latr.) which occur here commonly seem to harbor a larger number and a greater range of myrmecophiles than any other restricted group of ants with which we are acquainted. Their nest mates seem also to be more aberrant forms than those living with the other ants, — a condition which may possibly be produced by two unusual peculiarities of the Ecitons. Their eyes are very small (even absent in the worker of *E. cæcum*), and their power of vision must be correspondingly poor; then, too, their nomadic life must prevent many myrmecophilous forms from living with them, which would otherwise probably occur regularly. *Eciton schmitti* and *E. opacithorax* change the sites of their nests quite frequently and may often be seen marching in columns which extend over long distances, and at such times their guests must either travel along with them or be left to shift for themselves. *Eciton cæcum* is apparently always upon the move, but traveling below the surface of the ground and not venturing out, at least in the daylight.

Insects of three different orders are represented, Diptera, Hymenoptera, and Coleoptera; the new Diptera which belong to the family Phoridæ being among the most peculiar and remarkable of described myrmecophiles.

[1] *Contributions from the Zoölogical Laboratory of the University of Texas*, No. 25.

COLEOPTERA.

Carabidæ.

1. **Anillus affabilis** sp. nov.

Length 2 mm. Rufotestaceous, darker anteriorly, elytra lighter than head and thorax. Head smooth, shining; frontal impressions deep but not large. Antennæ testaceous, scarcely longer than head and thorax, slightly thickened towards apex. Palpi testaceous. Thorax distinctly wider than long, widest near the anterior angles, narrowest at base. The sides arcuate anteriorly and slightly sinuate posteriorly. Surface sparsely but distinctly pubescent. Side margin very narrowly reflexed, distinctly serrate, with four or five teeth near the slightly obtuse posterior angles. Median line delicately but distinctly impressed. Posterior transverse impression arcuate, the surface finely rugose behind it. Elytra considerably wider than thorax, distinctly serrate at the broadly rounded humeral angles and posteriorly to middle, where the teeth become obsolete. Side margin regularly arcuate, not at all angulated. A row of large punctures near the lateral margin, growing smaller and less distinct toward the apex, form an ill-defined, broad lateral stria. Dorsal striæ almost obsolete, the first three very faintly impressed, remainder indistinguishable. Elytra with three long lateral setæ, one at humeral angle, one at posterior third, and one subapical. Just anterior to the first long seta is a shorter one. Elytra sparsely clothed with erect pubescence. Legs pale testaceous.

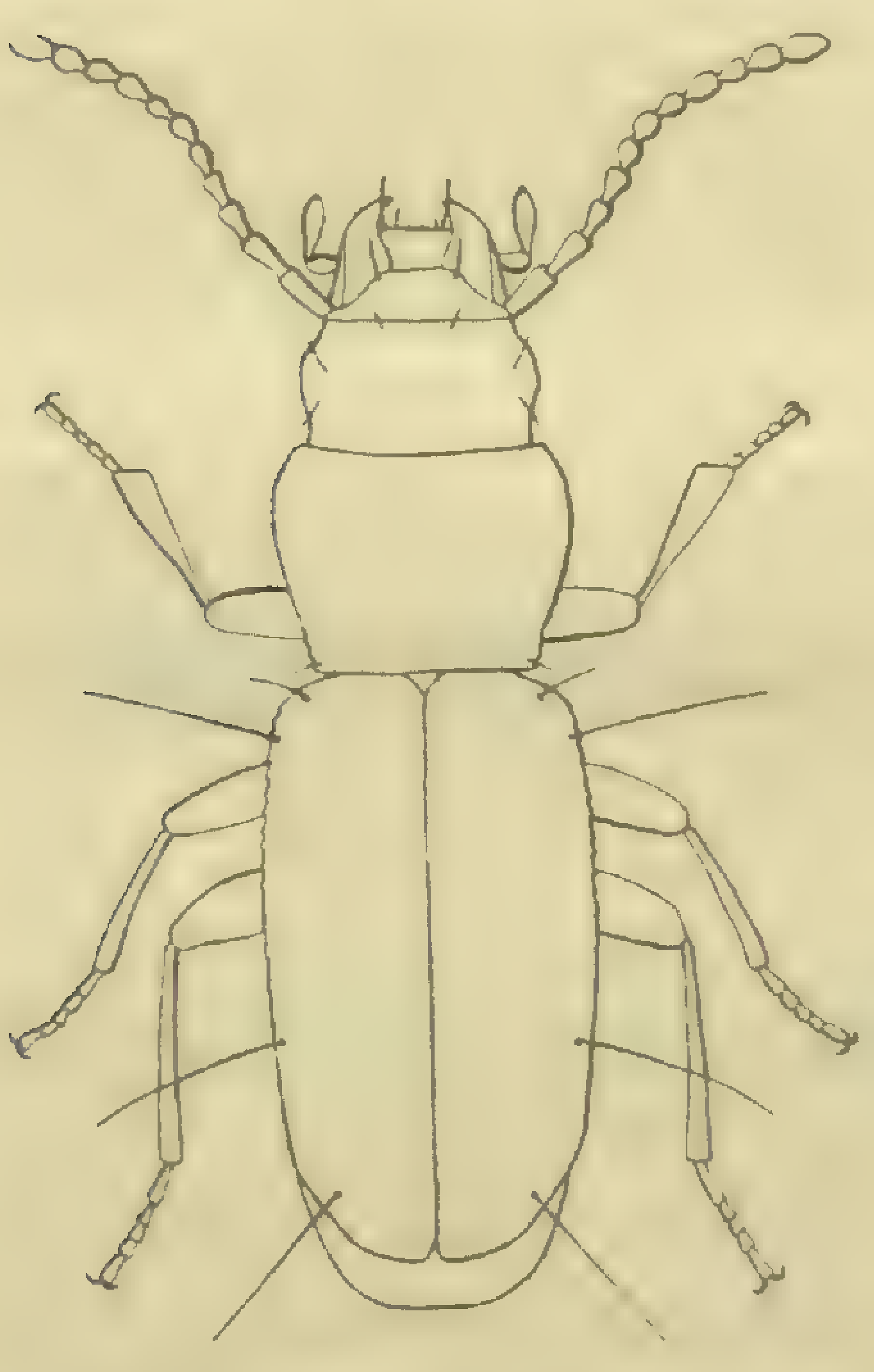


Fig. 1. — *Anillus affabilis* sp. nov.

Described from three specimens collected at Austin, Texas. Two were sifted from a nest of *Eciton cæcum* Latr., and one from a nest of *Solenopsis geminata* Fabr. While *A. affabilis* may not be strictly myrmecophilous, it is evidently partial to ant nests as a habitation.

This species most closely resembles *A. explanatus* Horn, from which it differs in having broadly rounded humeral angles, no angulation of the elytral margin, and by the three large elytral setæ.

The Californian *A. debilis* Lec. has been recorded from Texas by Schwarz, but the species here described differs in having the elytra serrate near the humeri. The original three-line description of *A. debilis* Lec.[1] would not serve for identification, but Horn[2] mentions that the elytra have the "margin not serrate."

Staphylinidæ.

2. **Ecitonidia wheeleri** Wasmann.[3]

A second specimen of this species was found April 20, 1901, in a nest of *Eciton schmitti* Em., the same species with which the type specimen was discovered. It is nearly as large as the worker ants and quite similar in color and movements, so that it is rather difficult to distinguish among a large number of ants. It is undoubtedly mimetic of the ants, but whether its resemblance enables it to deceive the ants as to its identity would seem very doubtful. The probability of its resemblance being due to some outside influence of natural selection is heightened by the fact that it must be exposed to insectivorous animals as it marches along in the columns of the ants, which are often seen in broad daylight and hence are exposed more than most species of ants with their attendant myrmecophiles.

3. **Ecitopora tenella** Wasmann.[4]

The original types of this species were part of a collection of numerous specimens from a nest of *Eciton schmitti* collected during October at Austin. Since that time we have found another species of this genus, the second to be recorded from North America.

North American Species of Ecitopora.

Thorax one and one-half times as wide as long, strongly arcuate on the sides, length 3 mm. . . . . *laticollis* sp. nov.

Thorax but slightly wider than long, almost straight on the sides, length 2–2.3 mm. . . . . *tenella* Wasm.

[1] *Trans. Amer. Phil. Soc.*, vol. x, N.S., p. 397.

[2] *Trans. Amer. Ent. Soc.*, vol. xv, p. 26.

[3] Neue Dorylinengäste, *Zool. Jahrb.*, Abth. f. Systematik, Bd. xiv, Heft 3, p. 69.

[4] *Loc. cit.*

4. **Ecitopora laticollis** sp. nov.

Length 3 mm. Pale fuscous; head black, elytra almost testaceous, thorax somewhat darker on the disk. First two abdominal segments with a lighter band at apex, abdomen elsewhere fuscous, legs alutaceous. Antennæ fuscous, paler on three basal joints; beyond the third joint they are very gradually thickened toward the tips, joints 4–10 being not quite twice as wide as long. Eleventh joint conical, slightly longer than the two preceding. Thorax one and one-half times as wide as head and one and one-half times as wide as long; widest at the middle, before which it is rather sharply narrowed; behind it is not so strongly narrowed. Front margin of the thorax somewhat concave on each side of the middle. Elytra not wider than the thorax at their base. Abdomen at base as wide as the prothorax, acuminate.

This species resembles *E. tenella* in general color and appearance, but is larger, with darker head and much wider thorax.

Described from numerous specimens collected in a nest of *Eciton schmitti*, February, 1901.

HISTERIDÆ.

5. **Ulkeus intricatus** Horn.[1]

Two specimens of this remarkable histerid were collected in a nest of *Eciton opacithorax* Em., March 24, 1901. They agree very well with Horn's original description, except that the frontal carinæ are divergent, not convergent above, and the network of fine raised lines upon the discal portion of the thorax is very faintly outlined in some places.

Horn makes no mention of the peculiar structure of the setæ with which the body is clothed. All the hairs upon the body are provided with long barbs. Those upon the head have the barbs shortest and scattered upon the central spine, but easily distinguished from it. Those upon the remainder of the body have no distinct central spine except at base, beyond which they split up into about five or six sharp barbs. Upon the dorsal surface of the body each forms a sort of stiff brush, which is flattened so as to appear very slender when seen from the side, but quite spreading when viewed from the front.

[1] *Trans. Amer. Ent. Soc.*, vol. xii (1885), pp. 142–143.

There can be no doubt that this histerid is a true myrmecophile of *Eciton opacithorax* Em., for Wasmann mentions it as occurring in North Carolina near a nest of the same ant.[1]

6. **Echinodes setiger** Lec.

We have found this histerid in company with *Eciton cæcum*, although very rarely. It is not uncommonly seen, however, in nests of *Solenopsis geminata* Fabr. and various species of Pheidole.

HYMENOPTERA.

Proctotrupidæ.

7. **Ceraphron croceipes** sp. nov.

Female. Length 1 mm. Black, shining, feebly punctured. Antennæ ten-jointed, black, scape ferruginous except at tip, where it is darker; pedicel pale at tip, constricted towards base, one and one-half times as long as first flagellar joint; second joint as long as first but stouter, not transverse; 3–5 equal in length, but gradually wider: 6 and 7 broadest, subequal, quadrate; last joint as long as two preceding, and as wide at base, acutely conically pointed at tip. Head finely punctured and white pubescent. Frontal cavity deep, circular in outline, bare, and impunctured. Groove in front of anterior ocellus punctiform. Mandibles dark yellow, palpi pale. Collar black, with a lemon-yellow stripe on each side. Thorax very delicately punctulate and white pubescent; mesonotum with a small tooth at each anterior angle. Axillæ broadly meeting in front of the scutellum, which is one-half longer than wide and fringed with stout golden bristles on the sides, except near the apex, its sides strongly areolated anteriorly. Postscutellum rounded at tip, its sides sinuate and white pubescent. Metathorax polished, its posterior angles produced and carinate. Metapleuræ smooth, obliquely striolate behind, and bounded by two carinæ above. Tegulæ piceous, wings subhyaline, slightly infuscated toward apex. Abdomen polished black, the second segment twice as long as the following segments, coarsely striolate at base, with a tuft of white pubescence at each anterior angle. Third and fourth segments about equal, fifth and sixth shorter and equal. Legs, including coxæ, wholly deep yellow, except the apical joint of all the tarsi, which is piceous. Posterior coxæ with a bunch of yellow hairs posteriorly.

Described from a female specimen collected in the galleries of a nest of *Eciton cæcum* Latr., at Austin, Texas, Feb. 3, 1901.

[1] Ein neuer Eciton-Gast aus Nord-Carolina, *Deut. Ent. Zeit.*, Heft 2 (1897), p. 281.

This species is quite closely allied to *C. pedalis, flaviscapus, glaber,* and *carinatus*, but is distinct from all by the form of the antennæ, axillæ, postscutellum, and maculation of collar.

Ecitonetes gen. nov.

Head globose, with a deep longitudinal frontal depression. Ocelli in a triangle, small and close together. Eyes oval, one-half as long as head and one-half as wide as long, coarsely faceted. Antennæ inserted on projections near the base of the clypeus; ten-jointed in female, scape stout, one and one-half times as long as eye, pedicel one-half longer than first flagellar joint, slender. Antennæ thickest at the seventh joint; last joint about one-third as long as scape and obtusely pointed at tip, equal in length to pedicel. Maxillary palpi long, four-jointed, last joint somewhat swollen; mandibles indistinctly bidentate. Thorax oval, the prothorax not visible from above. Mesonotum oval, rounded before and behind, considerably narrower than the head, and without any furrows or grooves. Scutellum absent, or at least not separated from that part of the mesonotum which extends over the place usually occupied by the scutellum. Metathorax produced into small teeth on extreme lateral and latero-posterior angles; much reduced, sloping on the sides and narrowed behind. Wings very small, about as long as distance between posterior ocelli or length of third antennal joint, with a strong vein along the costal margin and three strong bristles on the apical front margin, each about as long as the wing. Abdominal petiole very short, the abdomen squarely truncate at the base, where it is about as wide as the thorax. Abdomen oval, acuminate, with six visible segments, the first of which is as long as the rest together, second and third subequal, each about one-fourth as long as first. Legs rather short, stout; femora, especially posterior pair, swollen; anterior and posterior tibial spurs well developed. First joint of all tarsi elongated and longer than the three following; claws simple.

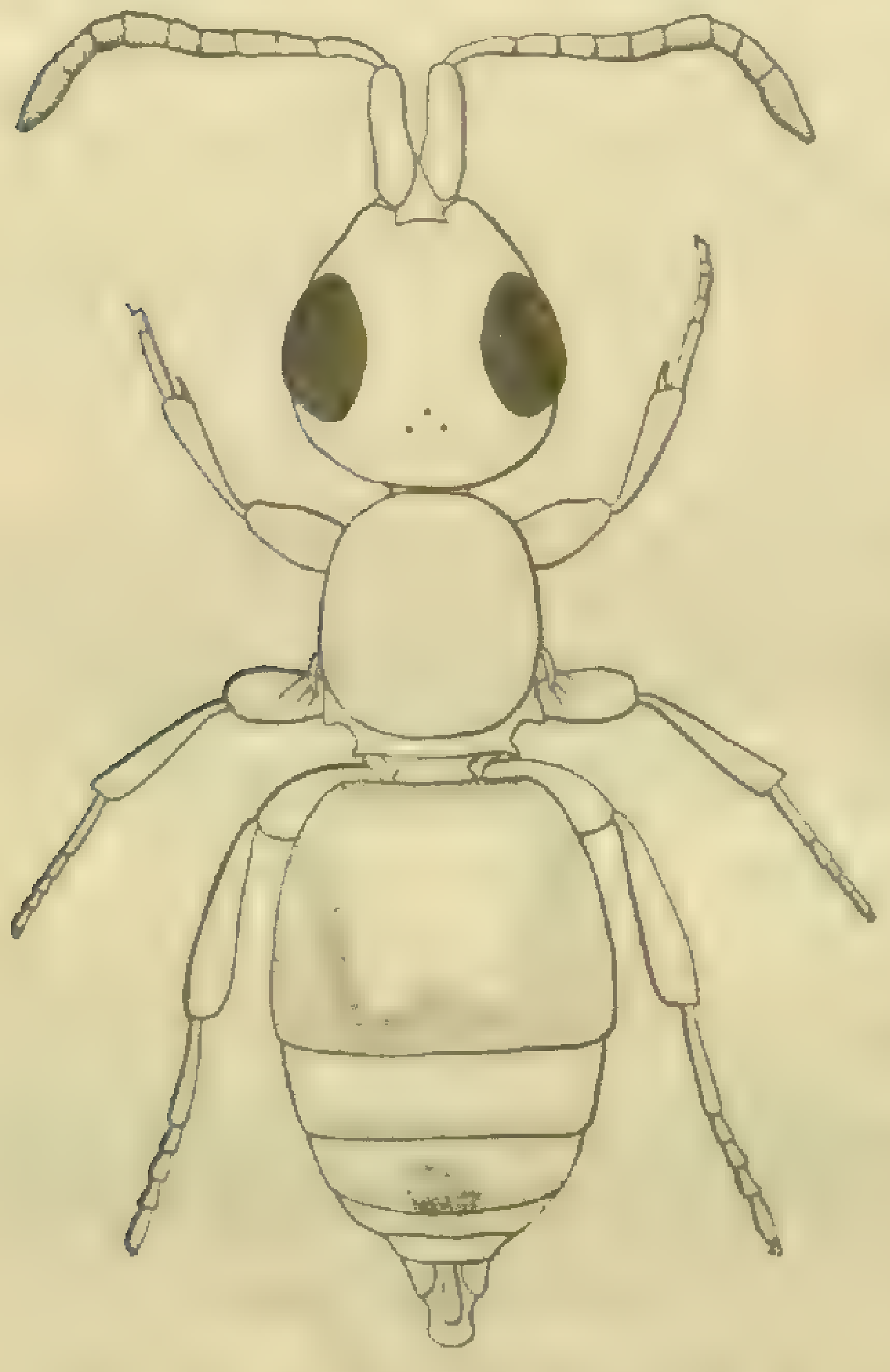


FIG. 2.—*Ecitonetes subapterus* ♀ sp. nov.

8. **Ecitonetes subapterus** sp. nov.

Length 2 mm. Light ferruginous, except the apical three joints of the antennæ, which are black; a sinuous dark band on the first abdominal segment, lighter toward the sides and hind margin; the narrow posterior margins

of second and third segments, and an oval spot on the third segment, dark. Eyes but little convex, finely hairy. Ocelli almost equidistant, small, and rather close together. Basal half of antennæ lighter than body, almost yellow. Thorax convex above, somewhat darker than the head. Abdomen smooth, without striæ or grooves, convex above and rather sharply convex below, so that the median line is quite sharply defined. Ovipositor black.

Described from one female specimen, collected in a nest of *Eciton cæcum* Latr., at Austin, Texas, during February, 1901.

While searching for the myrmecophilous Phoridæ in the nests of the large blind driver ant I chanced upon this small insect, which, from its actions and color, simulated one of the very smallest of the Eciton workers. Had it not been for its exceedingly small size and more robust build it would undoubtedly have passed unobserved among the ants. On examination with a lens, however, it was easily recognized as a proctotrupid. I have been unable to refer it to any described genus, although its place in the Ceraphronidæ is quite certain. It seems most closely related to Lagynodes Först., from which it differs by the ten-jointed antennæ, shorter scape, distinct ocelli, absence of groove on mesonotum, absence of scutellum, and shorter legs. The dark spot upon the third abdominal segment when strongly magnified is seen to consist of a network of raised black lines, which are coarser and more distinct posteriorly. This structure is interesting, as we know that at the same relative position on the abdomen of other Eciton myrmecophiles (Phoridæ) we also find a spot where the integument is peculiarly modified. This suggests some possible way that these blind ants may have of recognizing their habitual nest mates by means of markings which they can perceive by touch.

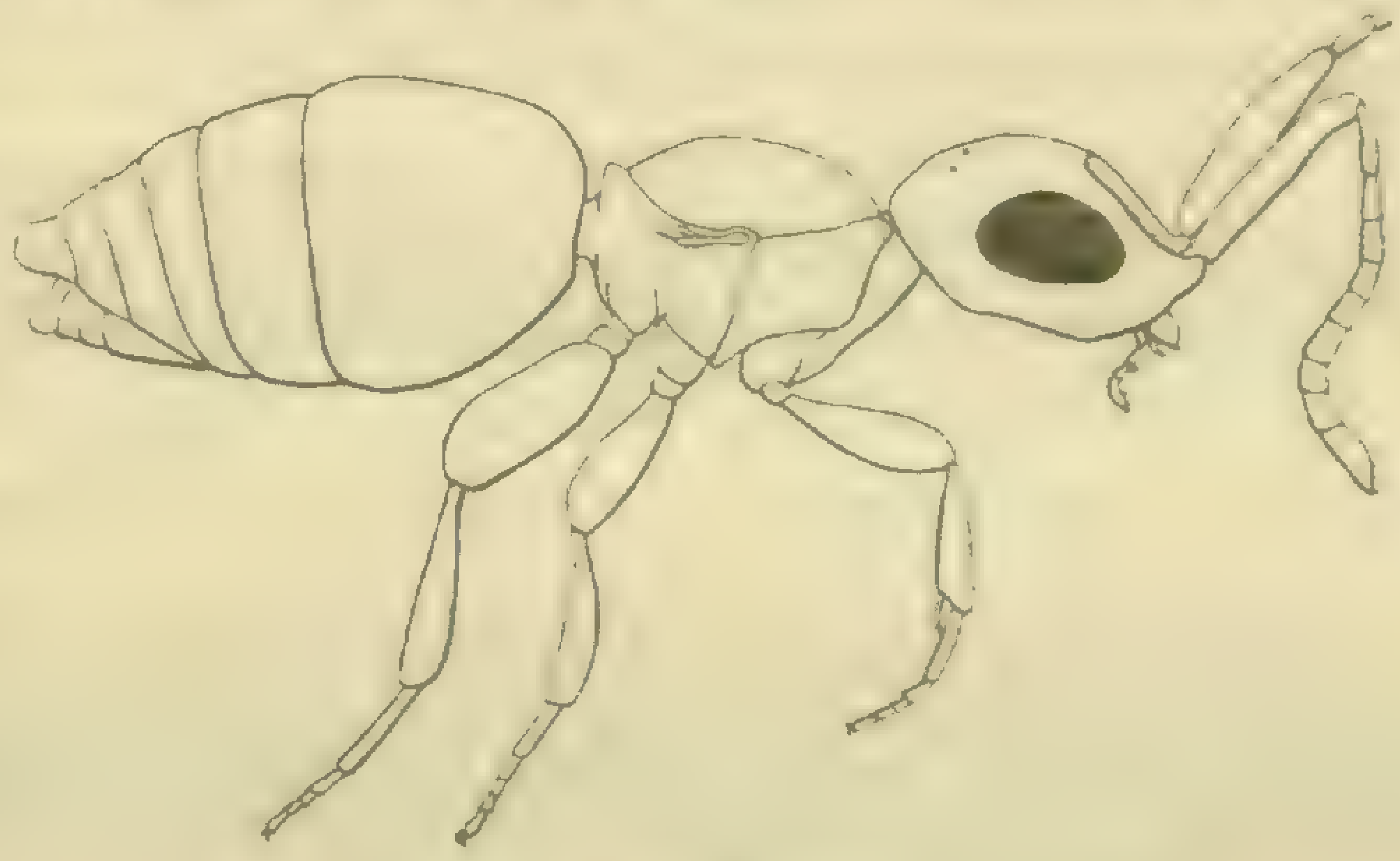


FIG. 3. — *Ecitonetes subapterus* ♀ sp. nov.

9. **Telenomus texanus** sp. nov.

Female. Length 1 mm. Black, shining, smooth, except thorax, which is very finely punctured. Antennæ piceous, lighter at base and apex of scape and apex of pedicel. Mandibles yellowish at tips. Head but little more than twice as wide as long antero-posteriorly, sparsely white pubescent. Face shining, smooth, vertex distinctly reticulate with fine impressed lines, reticulation extending down for some distance along the inner border of the eye. Front ocellus in a depression, lateral ones contiguous with eye margin. Eyes black, sparsely covered with short white hairs. Antennæ eleven-jointed; pedicel one and one-half times as long as first flagellar joint, which is nearly twice as long as thick; second and third thicker, but of same length as first; fourth small, transversely oval; fifth larger, transverse; three basal joints of club nearly equal, subquadrate; last joint conical. Thorax as wide as head, more thickly and finely hairy, and not so shining. It is also reticulate, but less noticeably than the head. Wings fusco-hyaline, marginal vein three-fourths as long as stigmal, wing margins strongly fringed. Abdomen very shining, slightly longer than thorax; second segment about as wide as long; the apical three segments fringed with fine white bristles. Legs and coxæ deep yellow: hind femora infuscated on middle portion, tibiæ, also, to a less degree. Tarsi paler, except last joint, which is black.

Described from a female specimen collected in a nest of *Eciton cæcum* Latr., near Austin, Texas, during March, 1901. The insect was found among the ants at a distance of several inches below the surface of the ground.

As all the other members of this genus are egg parasites it is possible that this species may be parasitic upon some guest of the Eciton, as is sometimes the case.

Telenomus texanus is most closely related to *T. geometræ* and *T. noctuæ*, from either of which it is easily distinguished by the form of the head, antennæ, and marginal vein.

10. **Phænopria acutiventris** sp. nov.

Female. Length 1 mm. Black, shining, impunctured. Antennæ rufo-piceous, the three-jointed club piceous; scape slender, arcuate; pedicel stout, oval, equal in length to first joint of club. First joint of flagellum one and one-half times as long as the second, which is moniliform, third and following joints increasing in size, moniliform except the last, which is oval and as long as the two preceding taken together. Posterior margin of head and anterior margin of collar white pubescent. Mesonotum considerably narrowed in front, convex. Scutellum flat at base and strongly convex on

the disk, without any pits or grooves. Wings hyaline, reaching considerably beyond the tip of abdomen, strongly fringed. Metathorax pubescent, dark rufous. Petiole and all the coxæ and trochanters saturate yellow, the former white pubescent. Femora and tibiæ strongly clavate, the swollen part piceous, becoming concolorous with the coxæ at the bases; tarsi slender, fuscous, darker at the tips. Abdomen highly polished, as long as head and thorax together, and conically pointed at the tip. Second segment reaching to a little beyond the middle of abdomen; third and fourth segments very short; fifth long and pointed, beset with a few stout white hairs.

Described from a female specimen collected in a nest of *Eciton cœcum* Latr., near Austin, Texas, during March, 1901.

I have placed this species in the genus Phænopria because of the form of the scutellum, although it resembles species of the genus Tropidopria in the form of the abdomen.

Phoridæ.

Acontistoptera gen. nov.

Head very broad, more than one and one-half times as wide as thorax at widest portion, widest at the front angles; half as long as wide; seen from above regularly arcuate in front, concave behind; front angles sharp, hind ones broadly rounded. Epistoma projecting slightly and visible from above as a narrow band extending between the antennæ. Eyes smaller than in Ecitomyia, oval, their longest axis equal to diameter of large antennal joint. Upper surface of head with a pair of small median macrochætæ, eight marginal ones on lateral and posterior edges, one over each eye, a bunch at front angles, and a regular series of closely placed ones along the front between the antennæ. Antennæ of the usual form, with an apical arista. Palpi projecting, of the usual form. Head seen from the side higher than long; front long, but slightly descending, rather acutely prolonged over the deep antennal cavity. Mentum very large, bristly along the front margin, and bearing several discal macrochætæ. Eyes very small, contiguous with front margin of the head below the middle of the antennal cavity; ommatidia hemispherical, few in number. Sides of head with a few macrochætæ below and behind the eye and a series of marginal ones from front edge to middle of lower margin.

Thorax small; when seen from above, much narrower than the head and greatly narrowed behind, the sides slightly sinuate; about one and one-third times as long as the head. The pleuræ partially visible from above, owing to the narrowness of the dorsum. Dorsum with a pair of very long, stout macrochætæ at the anterior angles and a shorter pair directly posterior to these. A pair of anterior, closely approximated, small discal macrochætæ;

two median larger and less approximate ones; and a pair of subapical ones. Scutellum very small, with a pair of dorsal macrochætæ. Thorax, seen from the side, but little larger than the head, strongly elevated in front; coxæ of the usual form. Legs rather slender, especially the tarsi. Spurs of four front tibiæ well developed. Wings about as long as the width of the thorax, arcuate, of nearly equal width and obtuse at tip, with a few short marginal bristles on its basal external margin. At about the middle these suddenly enlarge to form enormous macrochætæ, which continue to enlarge until at the tip they are more than twice as long as the wing and exceedingly stout. There are about ten of these large macrochætæ, which are all strongly, thickly, and almost scaly pubescent. Abdomen shaped as in Commoptera, without any indications of segments or sclerites, except the one probably corresponding to the fourth dorsal plate of Ecitomyia, which is small, with two macrochætæ, and has a chitinous ring extending from its posterior edge, which no doubt serves in connection with a gland like that of Ecitomyia. Abdomen everywhere sparsely and regularly finely bristly.

FIG. 4.—*Acontistoptera melanderi* ♀ sp. nov.

11. **Acontistoptera melanderi** sp. nov.

Length 1 mm.; of longest wing bristle, .4 mm. Light yellow, head darker, fuscous in places, the occiput irregularly lighter, a small yellow circular spot at the base of all the macrochætæ. Antennæ and palpi and lower part of the head yellowish white. Thorax above but little lighter than head. Wings almost white, their bristles black and very conspicuous. Abdomen, underside of thorax, and legs pale yellow. Legs finely black hairy and more deeply colored distally.

Described from a single female specimen[1] collected in a nest of *Eciton opacithorax* Em., March 24, 1901, at Austin, Texas.

[1] After this article had gone to press we were so fortunate as to find ten more female specimens in another nest of the same ant on December 6 and 7, 1901. They differ in no respect from the example figured, except that the abdomen is in

On overturning a large stone, beneath which a small colony of the ants had formed their nest, the fly in question was seen darting about upon the surface of the ground in the exceedingly nervous manner which characterizes the movement of Ecitomyia. It appeared much larger than any specimens of Ecitomyia, but, unfortunately, in capturing it the abdomen collapsed so that it has been impossible to determine whether the large size was due simply to a swollen condition of the abdomen or to something attached to it (possibly one of the very large eggs or a larva).

This form is at once recognized by the marginal row of enormous macrochætæ on the wings, which are also broader than those of Ecitomyia. The head is exceedingly large and wide in comparison with the extremely narrow thorax, which is quite different from that of any described phorid, in that the dorsum is so narrow that it allows the pleuræ to be visible from above along their entire length. The head is very much flattened and is remarkable for the row of closely placed macrochætæ along the anterior edge of the front. The eyes are about the size of those of Ecitomyia and have the same degenerate external structure. The mentum is large and more closely continuous with the sides of the head than is usually the case. The abdomen is wholly membranous, with the exception of a single segment (the fourth ?), which lies directly anterior to the abdominal gland instead of behind it as in Ecitomyia; a rather remarkable difference were it not known that in

Fig. 5.—*Acontistoptera melanderi* ♀ sp. nov.

some cases nearly twice as large, swollen out and filled with a liquid in which can be seen large developing eggs, some of which have the blastoderm completely formed.

another Texan genus, Commoptera, the gland is situated in the middle of the segment and could thus give rise independently to the condition of Ecitomyia or to that of Acontistoptera. The legs of this form are long and quite slender, the front ones are unfortunately broken off at the base of the femur in the only specimen I possess.

Xanionotum gen. nov.

Head broad, one and one-half times as wide as the dorsum of the thorax near the posterior angles; rounded triangular in shape, the anterior angles not at all evident, posterior ones rounded; twice as wide as long antero-posteriorly, when seen from above. Eyes barely visible from above at the extreme posterior angles of the head. Four marginal macrochætæ on middle of front, one on each side half-way toward the eye, another just in front of eye, one at posterior angle, and a pair of median posterior marginal ones and two widely separated discal ones. Antennæ rather large, of the usual form with apica arista, attached at the lower part of their unusually shallow cavities. Palpi visible from above for a distance equal to diameter of second antennal joint, rather slender, and with the usual bristles. Epistoma not visible from above. Ocelli absent. Eyes very small, situated slightly below and in front of the center of the sides of the head. Cheeks bristly, bearing a marginal row and an exceptionally strong macrochæta at the lower posterior angle. Proboscis nearly as long as height of head, acuminate, slightly geniculate at base. Thorax rounded, rather suddenly narrowed behind, much narrower than the head and a little longer; slightly wider than long. It is very broadly rounded on the sides and at the anterior angles, and not at all sinuate on the sides. Dorsum so wide as to almost entirely conceal the pleuræ. Scutellum very small, without macrochætæ. Metathorax visible behind it as a sclerite, which is but little larger than the scutellum. Dorsum with a pair of strong macrochætæ on the anterior angles, which are as long as the greatest width of the thorax; also a pair of strong postmedian

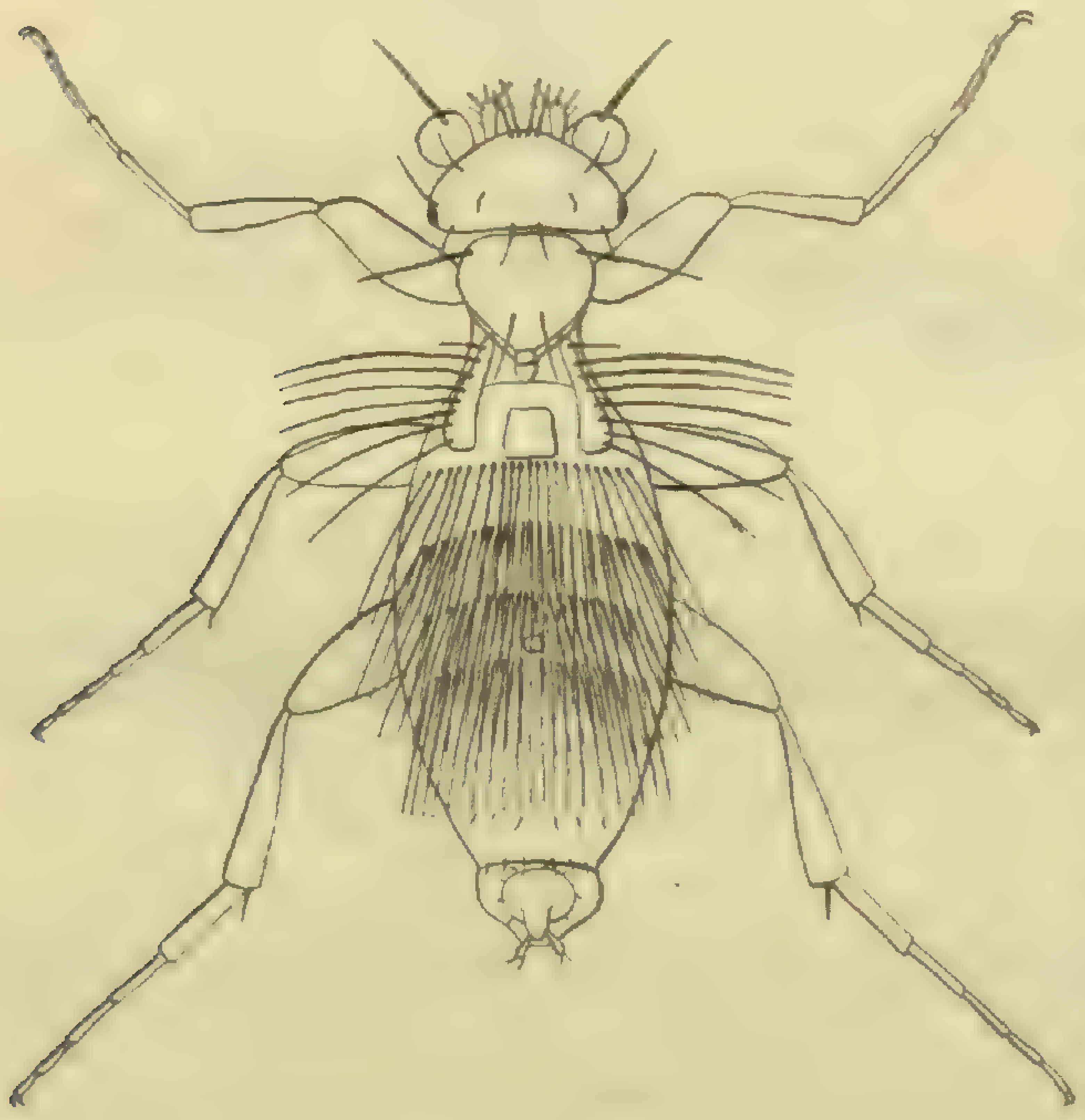


FIG. 6.—*Xanionotum hystrix* ♀ sp. nov.

discal ones. Thorax seen from the side considerably larger than the head, the dorsum regularly arcuate. Coxæ as usual, the anterior ones rather short; legs slender, the tarsi long, spurs of four posterior tibiæ well developed. Wings nearly as long as width of thorax, clavate, about two-thirds as wide at base as at apex, where they are rounded truncate. Wings very strongly bristly, the macrochætæ longer than the wing, the longest being one and one-half times as long, much more slender than those on the wings of Acontistoptera. All the bristles are on the distal three-fourths of the outer margin, about seven on the upper edge and three or four below. Abdomen of the usual shape with the dorsal plate of only the fourth segment visible; it is quadrate, somewhat narrowed in front and about as wide as diameter of second antennal joint. The gland opening on the fourth segment small and with the margin hardly at all thickened. The posterior margin of the four anterior abdominal segments marked off by wide rows of enormous macrochætæ which extend more than halfway across the abdomen. Each row contains about twenty bristles, those in the anterior rows being somewhat the longest and nearly equaling the wing bristles in length and thickness. Each bristle is not simple but composed of two distinct pieces, a short, stout basal piece, apparently contiguous with the abdominal cuticle and hollowed out into a spoon-shaped dorsal cavity at the apex into which the bristle is articulated. Fifth, sixth, and seventh segments faintly indicated by marginal bristles and by constrictions. Abdomen everywhere sparsely short hairy. Sexual organs smaller than usual.

12. **Xanionotum hystrix** sp. nov.

Length 1.25 mm. Light yellow, almost white, the head much darker above, except an irregular yellowish spot on the vertex: all the large macrochætæ fuscous. Thorax tinged, darker above, especially in front. Legs concolorous with the body, tarsi darker yellow, legs finely black hairy.

Described from a single female specimen[1] collected at Austin, Texas, March 24, 1901, in the same nest of *Eciton opacithorax* in which the specimen of *Acontistoptera melanderi* was discovered. Although the nest was carefully sifted it revealed no other specimens of either form.

This form is undoubtedly the most remarkable phorid which we have collected here, and although it was so closely associated with the other new genus here described, there seems to be no possibility of considering them as dimorphic forms of a single species, as almost every part of the body is quite different in

[1] We have since found another exactly similar specimen with the same ant, December 6, 1901.

structure. It has been placed in a different genus on account of the different shape and chætotaxy of the head, its shorter thorax with broader dorsum, abdomen with first dorsal plate present and fourth wanting, and with the four rows of large spines. We must of course expect to find a greater disparity between these greatly degenerate forms than among more specialized Diptera, but to include two such dissimilar species in the same genus is hardly consistent with the importance usually laid upon structural characters.

FIG. 7. — *Xanionotum hystrix* ♀ sp. nov.

The head is very strongly arcuate in front and the lower margin is not visible from above. The antennæ are larger than in the other genus, and the eyes slightly smaller. The thorax is not so unusual in shape, although the pleuræ are slightly visible from above on the posterior part. The thorax in both genera is, however, a closer approach to the typical dipteron thorax than that of Ecitomyia. The rows of closely placed abdominal spines are an unusual development, which give the abdomen a most peculiar appearance. In this form the opening of the abdominal gland is near the middle of the fourth segment.

13. **Ecitomyia wheeleri** Brues.[1]

This form is an habitual nest mate in most of the *Eciton cæcum* nests which we have seen in this region, although the imagines become rare and perhaps disappear entirely upon the approach of the summer heat and drought.

The two specimens from a nest of *Eciton schmitti* Em. may possibly have represented another closely allied species, but were unfortunately sectioned before it was recognized that numerous species of myrmecophilous Phoridæ occur in this region.

[1] *American Naturalist*, May, 1901.

ON THE STRUCTURE AND CLASSIFICATION OF THE TREMATASPIDÆ.[1]

WILLIAM PATTEN.

Of all the families usually included in the problematical and heterogeneous group of animals called the "ostracoderms," none is more interesting to the morphologist than the Tremataspidæ, as the little known about them shows they possessed a most extraordinary structure, unlike in many respects that of any other group of animals. While the character of the trunk scales, of the orbits and other sensory openings, the minute structure of the shell, and the presence of the newly discovered lateral-line system clearly indicate the affinity of Tremataspis with Pteraspis, Cephalaspis, and Pterichthys, and through them with the true vertebrates, other features, such as the general shape of the shield and its more superficial texture, which have long been a source of perplexity to the paleontologist, clearly point to the affinity of Tremataspis with arthropods like Limulus, Apus, and the trilobites.

The importance of the Tremataspidæ to the morphologist also lies in the fact that while the specimens are rare and more or less fragmentary, they are usually well preserved and give fair promise that ultimately we shall be able to decipher in detail the structure of all their hard parts. This knowledge will certainly throw much light on the morphology of the whole group of ostracoderms, and may afford decisive evidence of the genetic relationship between the vertebrates and invertebrates.

When, therefore, through the generosity of the administration of Dartmouth College, I was granted a half-year's leave of absence, I decided to make as thorough an investigation of the ostracoderms as my time and means would allow, with the special object of determining whether any evidence could be

[1] This paper is an abstract of one about to be published in the *Memoirs of the Imperial Academy of Sciences of St. Petersburg.*

found bearing out our assumption that they are an intermediate group of animals related on one hand with the arthropods and on the other with the vertebrates. My plan was to study all the most important collections in Great Britain and the Continent and to purchase or collect material that might be used for detailed study by sectioning or by other methods, as the

FIG. 1. — A partial reconstruction of the ventral side of the head of Tremataspis. Enlarged about 2⅓ diameters. The figure was made from a wax model constructed after several specimens and fragments in the University and the Imperial Academy, at St. Petersburg, and in the Dartmouth College Collections.

valuable type specimens permanently preserved in museums could not be utilized in this manner.

It did not take long to discover that the following out of the second part of my program, the collection of Thyestes and of Tremataspis, was a most difficult task. So far as I know, every fragment of these two genera has been taken from a shallow pit about four feet deep and covering perhaps an area of three or four hundred square yards, hidden in the heart of the remote and otherwise little-known island of Ösel in the Baltic Sea.

The mysterious treasures of this classic spot have drawn to its sides many famous scientific men from all quarters of the globe. From time to time during the last forty years or more many beautifully preserved eurypterids and an occasional Trema-taspis have been taken from this insignificant pit in a pasture. During the past twelve or thirteen years the spot has been

FIG. 2.—The dorsal surface of the head of Tremataspis.

worked more systematically by Mr. A. Simonson, who has collected, with very few exceptions, all the material of Tremataspis and Thyestes that has ever been found; and yet, with the most careful and painstaking work, and with considerable assistance from common laborers, two or three, very rarely four, fragmentary heads of Tremataspis are all that reward the labors of a whole summer. I considered myself fortunate, therefore, in being able to purchase nearly all of the fossils collected by Herr Simonson during that season. The collection contained many specimens of Thyestes, Cephalaspis, and Bunodes, together with four heads of Tremataspis, some of which were in exceptionally

good condition; but, unfortunately, none of the last-named genus showed the presence of the plates in the oral region.

All of these specimens have been added to the collections in Butterfield Museum of Dartmouth College.

The four heads of Tremataspis (which have been cleaned with great care) have enabled me to make out several new details concerning the sensory openings on the dorsal surface; they were the first to show the system of lateral-line pits, although these pits were afterwards seen on most of the St. Petersburg specimens. But they were of special value in that they enabled me to work out the structure of the anterior margin of the dorsal shield and to discover three new openings

Fig. 3. — Head of Tremataspis seen from the side.

in the series of so-called gill openings described by Rohon. These parts in the Petersburg material were absent or had been destroyed by rough handling.

The reconstruction of the oral region was made from a study of the single specimen and its cast that have already been described by Rohon. The original fossil had lost many details through repeated handling and the apparently incautious attempts to clean out the matrix between the edges of the plates. The original mold, however, was in nearly perfect condition, and by taking several impressions of it in dentist's wax a beautiful reproduction of the original untouched fossil was obtained, from which were worked out all the details in the arrangement of the oral plates shown in the restoration. These casts and the enlarged model are now preserved in Butterfield Museum at Dartmouth College.

Our observations on the structure of Tremataspis have brought out the following principal facts:

The *Lateral-Line Organs of Tremataspis* consist of a series of shallow groove-like dots and dashes, arranged in linear series on the dorsal surface of the shield. We distinguish a

circumorbital, marginal, anterior transverse, and a posterior dorsal line. The first two lines appear to correspond with the circumorbital, and the trunk line of Pterichthys. The circum-orbital line is represented in Tolypaspis by a V-shaped ridge.

The Sensory Openings of the Dorsal Shield. — There are four centrally placed openings and two pairs of marginal ones on the dorsal shield of Tremataspis. Interpret these openings provisionally as follows: the posterior central opening is that of an olfactory organ; the three anterior central ones belong to the median eye; the anterior lateral openings contain the lateral eyes, and the posterior lateral pair, a segmental sense organ comparable with the dorsal organ of embryo Limuli.

The olfactory opening and both pairs of lateral openings in all well-preserved specimens possess sharply scalloped margins and a reticulated bony floor. Transverse sections show that the floor is an extension of the inner layers of the shell.

In transverse sections through the frontal depression the median slit is seen to be a true perforation of the shell, its infolded margins forming a short flattened tube.

The median orbits are separate, nearly spherical chambers, enclosed in a network of bony tissue formed by ingrowths of the inner layers of the shell. The narrow median canal that appears to connect the two orbits is closed by a deep-lying bony floor, also formed from the inner layers of the shell.

The *lateral eyes* were small and subordinate in function to the median ones. They probably occupied the anterior pair of marginal openings, the rounded incisions on the edge of the openings possibly indicating the presence of compound eyes, consisting of a few large ommatidia. The lateral eye orbits agree with those of Limulus in being shut off from the interior of the head by a bony network arising from the inner layer of the shell.

The *posterior marginal openings* agree in position with the so-called dorsal organs of Limulus, a pair of segmental sense organs serially homologous with the lateral eyes and lying in larval Limuli opposite the fourth pair of thoracic appendages.

The Median Eye. — The three anterior median openings I have compared with the triocular median eye of Limulus, Apus,

trilobites, Merostomata, and other arthropods, but not with the three frontal ocelli of adult insects. In Limulus, where the structure and development of this organ is best known, the retinas of the median ocelli arise from two pairs of segmental sense organs, that during the closing in of the brain migrate from the margins of the cephalic lobes to the roof of the fore-brain vesicle. Here the ocelli come to lie at the blind end of a long tubular outgrowth of the brain roof. The distal end of the tube then divides into two vesicles, lying in the median line, one in front of the other. The united retinas of one pair of ocelli form one of the vesicles and, at a considerably later period, lie in a degenerate condition, deeply buried beneath a median tubercle on the dorsal surface of the head. The other two retinas lie close together in the second vesicle, beneath two median lenses. These two terminal vesicles are found in a more or less modified form in many Crustacea and without doubt in the trilobites and Merostomata also, since the arrangement of their surface lenses is, in some case, precisely the same as in Limulus. The median eye of Tremataspis, like that of Limulus, probably consists of a complex group of three ocelli derived from the incomplete fusion of two pairs. They were, no doubt, true cerebral eyes, lying at the end of a tubular outgrowth of the brain. The distal end of this tube was probably bifurcate, the anterior vesicle containing one pair of ocelli lying beneath, or in, the median pit and the posterior vesicle lying in the paired median orbits. The anterior and posterior vesicles of Limulus and Tremataspis are represented in true vertebrates by either the vesicular ends of two separate outgrowths from the brain roof, one behind the other, or by two terminal vesicles, one in front of the other, arising from a common tubular outgrowth.

According to this view, the visual organs of vertebrates are derived from three pairs of segmental sense organs, originally situated near the margins of the cephalic lobes. The median eyes, which were the most anterior, were the first to be converted into cerebral eyes of the vertebrate type. This change took place in the arthropods, the various steps in the process being clearly seen in insects, crustaceans, and arachnids. The transfer of the lateral eyes to the cerebral vesicles and

their consequent inversion took place much later, probably in the intermediate type of animals to which the Trematasipdæ belong. It was during this period that the median eyes reached their highest development and the lateral eyes degenerated or, in some cases, disappeared completely from the surface. We have no means of knowing whether their temporary decline in functional importance was the cause, or the result, of their transformation into eyes of the cerebral type.

The *postorbital opening* probably contained the forerunner of the vertebrate olfactory organ. I have identified it with the frontal organ of Limulus, Branchipus, Apus, and others. This organ in the arthropods presents extraordinary variation in its position, but can always be identified by the peculiar histological structure of the terminal organ and its nerve, and by the origin of the nerve in the brain. In Limulus, no doubt, the organ was originally a visual organ serially homologous with the lateral and median eyes. In the adult it lies on the ventral side in front of the cheliceræ. It gradually loses the histological characters of a visual organ and finally presents many points of resemblance to the olfactory organ of a vertebrate, especially in the structure and relations of its nerves. The hypostomeal eyes of trilobites are very probably homologous with the olfactory organs of Limulus. In Branchipus the same organ has moved from its original position on the ventral surface to a point on the dorsal surface almost as far back as the median ocellus. In Apus the two organs have moved still farther back and have united behind the median ocellus to form an unpaired organ in precisely the same location as the post-orbital opening of Tremataspis.

The *Oral Plates* have been worked out anew from the single fossil and its cast that was used by Rohon. My description differs from his in several very important respects.

According to my interpretation of this important fossil there are on each side nine large oral plates arranged in four rows. Some of the marginal plates are provided with one or more rounded incisions lying opposite corresponding incisions of the ventral and dorsal shields. The marginal plate of the fourth row is probably a compound plate. There is a row of four or

five small plates on each side, just behind the anterior margin of the dorsal shield.

A small triangular median plate lies in the anterior oral region. Its anterior margin seems to be articulated to the hinge-like process on the anterior median margin of the dorsal shield. The outer surface of the plate is smooth and provided with a low, keel-like ridge that gives it the appearance of the rostrum of an arthropod. Its apex lies considerably below the surrounding surface in a median depression that probably leads into a small circular oral cavity like that of an arachnid. There is no trace of a large transverse oral opening, like that described by Rohon, between the anterior plates and the anterior ventral margin of the dorsal shield.

The *anterior margin of the dorsal shield* is deflected sharply downward to form a low wall in front of the oral region. A small keel lies in the middle line on the posterior surface of the wall, with its rounded edge directed backwards. Two rounded toothlike projections of the rim, directed ventrally, lie on either side. The lateral margins of the dorsal shield are folded sharply toward the ventral median line and present three large rounded incisions that must be regarded as a forward extension of the series of six incisions of the ventral shield described by Schmidt and Rohon.

The Appendages. — The most anterior incision is the largest and is clearly the same as that so well seen on the margin of the dorsal shield in Tolypaspis, Cyathaspis, and Pteraspis, and which has been regarded as an opening for the lateral eye. Lindström's important discovery of an appendage in Cyathaspis, my own discovery of fragments of the appendages in Tremataspis, and a renewed examination of the pteraspids in the British Museum indicate that in these four genera the large anterior marginal incision served for the attachment of an oar-like appendage similar to that in Pterichthys and Bothriolepis. The remaining openings, which are unquestionably serially homologous with the first, must have served for the attachment of other appendages of a similar nature. They decreased in size from before backwards, and were possibly too delicate to be well preserved in a fossil condition.

The Entapophyses and the Trabeculæ.—It is doubtful whether the endolymphatic ducts of Rohon are actual perforations of the shell. In sections they are seen to be deep tubular infoldings, probably closed at the inner end. They appear to be comparable with those infoldings, or entapophyses, on the dorsal shield of Limulus which serve for the attachment of dorso-ventral muscles. This interpretation is strengthened by the fact that serial sections show the presence of another pair of bony ingrowths, just behind and in line with the so-called endolymphatic ducts. They are long deep plates that unquestionably serve for the attachment of muscles, since the frayed-out ossified tendons are still attached to their inner ends. These entapophyses are of great importance, as they indicate a similar arrangement of muscles and appendages to that seen in Limulus. They probably served for the attachment of dorso-ventral muscles, arising from the dorsal surface of the cartilaginous cranium and from the various pairs of cephalic appendages.

The presence of a similar set of muscles in Pteraspis and Cyathaspis is indicated by radiating impressions or lobes on the inner surface of the shell, similar to the radiating muscle markings on the dorsal wall of Limulus.

Transverse sections of the whole head show that the shell is specially thickened in the region of the crista occipitalis, and that the margin of the shield is considerably strengthened by a network of bony trabeculæ uniting the edges of the dorsal and ventral walls. The marginal trabeculæ are very similar to those I have described in Limulus. The marginal cells of Eukeraspis are probably produced by a special arrangement of these trabeculæ.

A loose network of bony trabeculæ is also developed round the median and lateral openings of the dorsal shield and along the incisions of the ventral wall where the appendages are attached. With the above exceptions, the inner surfaces of the dorsal and ventral shields are smooth.

The minute structure of the shell of Tremataspis and other members of the ostracoderms can be best explained, as we have pointed out elsewhere, on the assumption that it is a modification of a three-layered dermal skeleton similar to that of Limulus.

The Resemblance between the Trematasp dæ and the Arthropods.—The following summary of the principal characteristics of the Tremataspidæ shows how strongly they resemble the arthropods, and how surprisingly the resemblance has been strengthened at certain points by important discoveries in unexpected directions.

The Tremataspidæ resemble the arthropods in (*a*) their general arthropod appearance, (*b*) in the minute structure of the shell, (*c*) in the structure and arrangement of the openings for the eyes and olfactory organs, (*d*) in the character and arrangement of the oral plates, (*e*) in the absence of vertebrate jaws and mouth and in the presence of a small centrally placed oral opening similar to that of an arachnid, (*f*) in the presence of numerous pairs of jointed appendages.

The presence of segmented appendages in Trematasp s and related forms is indicated by the following evidence: (1) the presence of a pair of oarlike jointed appendages, unlike those of any true vertebrate, in Pterichthys, Bothriolepis, Cyathaspis, Pteraspis, Tolypaspis, and Trematasp s; (2) the presence of a fringe of jointed and movable appendages (25–30 pairs) along the ventral margin of the trunk of Cephalaspis; (3) the presence of a pair of crushing mandibles like those of an arthropod in the head of Cephalaspis; (4) the presence in Pterichthys, Bothriolepis, and Trematasp s of oral plates that appear to be movable laterally, like the jaws of an arthropod; (5) the presence in Trematasp s of a series of eight other pairs of openings like the ones to which the large swimming appendages are attached; (6) the presence in Trematasp s of two pairs of entapophyses which, like those in Limulus, apparently serve for the attachment of muscles moving several pairs of appendages; (7) the presence in Cyathaspis and Pteraspis of from four to six radiating grooves on the inner surface of the dorsal shield, which, like similar markings in Limulus, indicate the points of attachment of dorso-ventral muscles moving several pairs of appendages.

The concurrent testimony, from so many different and independent sources, to the fundamental similarity between the Tremataspidæ and the arthropods shows very clearly that the resemblance between them is due, neither to incidental

parallelism, nor to mimicry, but to genetic relationship and community of origin. It could not have been a remote relationship, signifying merely a common origin of both types from some annelid ancestor, because the resemblance consists in the common possession of highly specialized structures characteristic of the fully established arthropod and vertebrate types.

The genetic relationship, therefore, between the Trematasspidæ and the arthropods can mean nothing less than the derivation, through changes in structure and function, of one type from the other.

But we must not too hastily conclude that the Trematasspidæ are true arthropods, and by transferring them from one group to the other avoid the real problem at issue. We cannot so easily ignore the profound significance their structure has for the origin of vertebrates. Their vertebrate affinities are too obvious to be denied.

It is quite out of the question to separate the Trematasspidæ very far, either from the Cephalaspidæ on the one hand, as is conclusively shown by the similarity in the structure of their orbits, or from the Pteraspidæ and Pterichydæ on the other, as is shown by the appendages and the lateral-line markings, or from either, as is shown by the microscopic structure of the shell. The whole group must be kept together. But, as it is quite impossible to include in the arthropods a group of animals, nearly all of which have osseous dermal skeletons, and some of which have such characteristically vertebrate bodies and fins as the Cephalaspidæ and Pterichydæ, or to include in the vertebrates animals having many pairs of jointed appendages, it becomes necessary to create for them a new class, one that shall occupy a position between the true vertebrates and arthropods, and unite these two great groups into one compact phylum.

I propose for this new class the name Peltacephalata, and include in it forms like Pterichthys, Cephalaspis, Pteraspis, Trematasspis, and related genera. The class may be provisionally characterized as follows:

The Peltacephalata were arthropod-like animals, moving about through the soft mud on the bottom of shallow waters,

in the typical arthropod position. In many cases most of the body was probably concealed, leaving only the prominent median eyes exposed. The presence of paired oarlike appendages indicates the power of free swimming, but the more or less rigid and clumsy appendages and heavily armored body could have produced little more than brief, spasmodic excursions, like those of adult Limuli and eurypterids, or jerky, intermittent flights through the water, like those of a copepod. And, just as in these examples the shape of the body and the position of the appendages in reference to the center of gravity compel the free-swimming individual to reverse the usual position of dorsal and ventral surfaces, so in the Peltacephalata the prevalence of the same conditions must have forced them, after leaving the bottom, to turn over and swim with the neural side uppermost, in the true vertebrate position. The swimming movements were probably aided in some cases by numerous small appendages on the head and trunk. Fishlike caudal fins and tail were used in swimming and in reversing the position of the dorsal and ventral surfaces.

It was not till this new method of locomotion had completely replaced the old that the eyes left the hæmal surface (their position in most adult arthropods) and returned to the neural surface of the body (their position in embryo arthropods and their permanent position in vertebrates).

The *exoskeleton* was a true dermal armor of ectodermic origin, intermediate between the type presented by Limulus and that of the more modern vertebrates. It consisted of three principal layers, the middle one containing large, more or less regular spaces or cancellæ. The matrix was strongly laminated and penetrated by numerous dentine-like tubules, or pore canals, and contained either unipolar or multipolar osseous lacunæ. The trunk was covered with rhomboidal scales or with segmentally arranged ringlike plates. The presence of a system of superficial sense organs is indicated by numerous pitlike markings arranged in linear series.

A flattened cartilaginous cranium was present, but notochord and vertebral arches were absent or rudimentary. Median and lateral eyes were enclosed in bony orbits, sometimes protected

by hard convex coverings continuous with the outer layers of the shell. The median eye was large, complex, and important functionally. It consisted of two pairs of ocelli, one pair completely united in the median line and the other nearly so. The lateral eyes were reduced in size and in functional importance. The nasal pit was unpaired and, in some cases, situated behind the median eye. The mouth was small, circular, and situated near the center of a group of oral plates. No upper and lower jaws were present.

The head of the Peltacephalata may be regarded as a modification of the cephalothorax of an arthropod ancestor, consisting of three principal groups of segments, namely: the preœsophageal, including all the parts derived from the cephalic lobes; the true thoracic segments; and the highly modified vagus segments, formed by the forward migration and their complete union with the thorax of from two to four abdominal segments. The brain, like that of vertebrates, probably consisted of three groups of neuromeres derived from these three sources.

The Peltacephalata have their nearest relatives among the known invertebrates in the Trilobita and Merostomata, having retained to a considerable extent the general shape of the body, the structure of the head, and the mode of life characteristic of these arthropods.

Sufficient data are as yet unavailable for a permanent arrangement of the Peltacephalata into orders and families, but some modifications of the old arrangement may be made to advantage. The old subdivisions into Osteostraci and Heterostraci, proposed by Lankester, should be abandoned, as they do not mark natural divisions. The discovery of heavily armored oarlike appendages in Cyathaspis and Tremataspis, and their probable presence in Pteraspis and Tolypaspis, unite these genera more closely with one another and with the Pterichydæ than ever before. It is therefore inadvisable to isolate the pteraspidian section merely on the absence of multipolar bone cells, unless the Pterichthydæ are united with the remaining families under the heading Osteostraci. But such an arrangement would not sufficiently emphasize the resemblance between

the oarlike appendages of Cyathaspis, Tremataspis, and Pterichthys, and the difference between these appendages and those of Cephalaspis.

Moreover, the Pteraspidæ approach the Pterichydæ more closely than do the Tremataspidæ in the division of the cephalic buckler into separate plates, and in its separation into a true cephalic or rostral portion bearing the median eyes, and a thoracic one to which the oarlike appendages are attached. On the other hand, Tolypaspis, which must be placed close to Pteraspis and Cyathaspis on account of the minute structure of the shield, shows no trace of a subdivision of its dorsal shield into separate plates.

It seems to me, therefore, that we must recognize four subdivisions of the Peltacephalata of about equal value, *viz.*, the Pteraspidæ, Tremataspidæ, Pterichydæ, and Cephalaspidæ. The Cephalaspidæ occupy a somewhat isolated position on account of the very peculiar shape of the head and the position and character of the appendages, although on the other hand, as shown by the connecting form Thyestes, a close relationship between Cephalaspis and Tremataspis is indicated by the resemblance between their median, lateral, and postorbital openings.

The Pterichydæ and Tremataspidæ are bound together more closely than before, owing to their possession of oarlike appendages, large centrally placed orbits, and to the arrangement of the so-called lateral-line organs and oral plates.

The Syncephalata. — For the great phylum of the animal kingdom formed by the union of the vertebrates and arthropods I propose the name Syncephalata. The delimitation of the Syncephalata can be only roughly determined, especially at the lower end of the phylum. The main stalk consists of the Arachnida (including the Trilobita, Merostomata), the Peltacephalata, and the Vertebrata. The point of divergence from the main stalk of such groups as the Insecta, Crustacea, and the simplified and aberrant forms, like the Ternicata, Amphioxus, Balanoglossus, and others, are of minor importance and do not concern us here.

The justification of the term Syncephalata lies in the fact that in this vast series of segmented animals the concentration

and specialization of the anterior body segments into a head region is definitely begun and completed. It is only when this group is viewed as a whole that we see these momentous structural advances in their true perspective, and can follow the endlessly varied theme that leads steadily and consistently onward toward the completion of the most complex organic structure that has ever been produced, the vertebrate head.

Dartmouth College,
January, 1902.

VARIATION IN THE POSITION OF THE ADDUCTOR MUSCLES OF ANA-DONTA GRANDIS SAY.

ELLIOT R. DOWNING.

Through the kindness of Mr. Frank C. Baker, curator of the Chicago Academy of Science, I have had the privilege of examining and measuring a number of exceptionally perfect shells of *Anadonta grandis* Say. These shells were taken in August, 1897, from "South Pond," Lincoln Park, Chicago, where they were closely associated as a colony. As the pond was thoroughly cleaned four years previously, the age of the oldest shells is definitely known. Not only do the annual limits of growth show, but internally the muscle scars and the paths of migration are very distinct (see figures).

During part of the year shell growth occurs rapidly and muscle migration is also rapid ; again, growth nearly ceases, and the narrow dark band is deposited. During this slow growth the muscle is about stationary, and then the very distinct scar is formed.

The questions which I wished to settle were :

1. Does the muscle in its migration move at a rate proportional to shell growth, so that the muscle retains a fixed relation to the shell's proportions ?

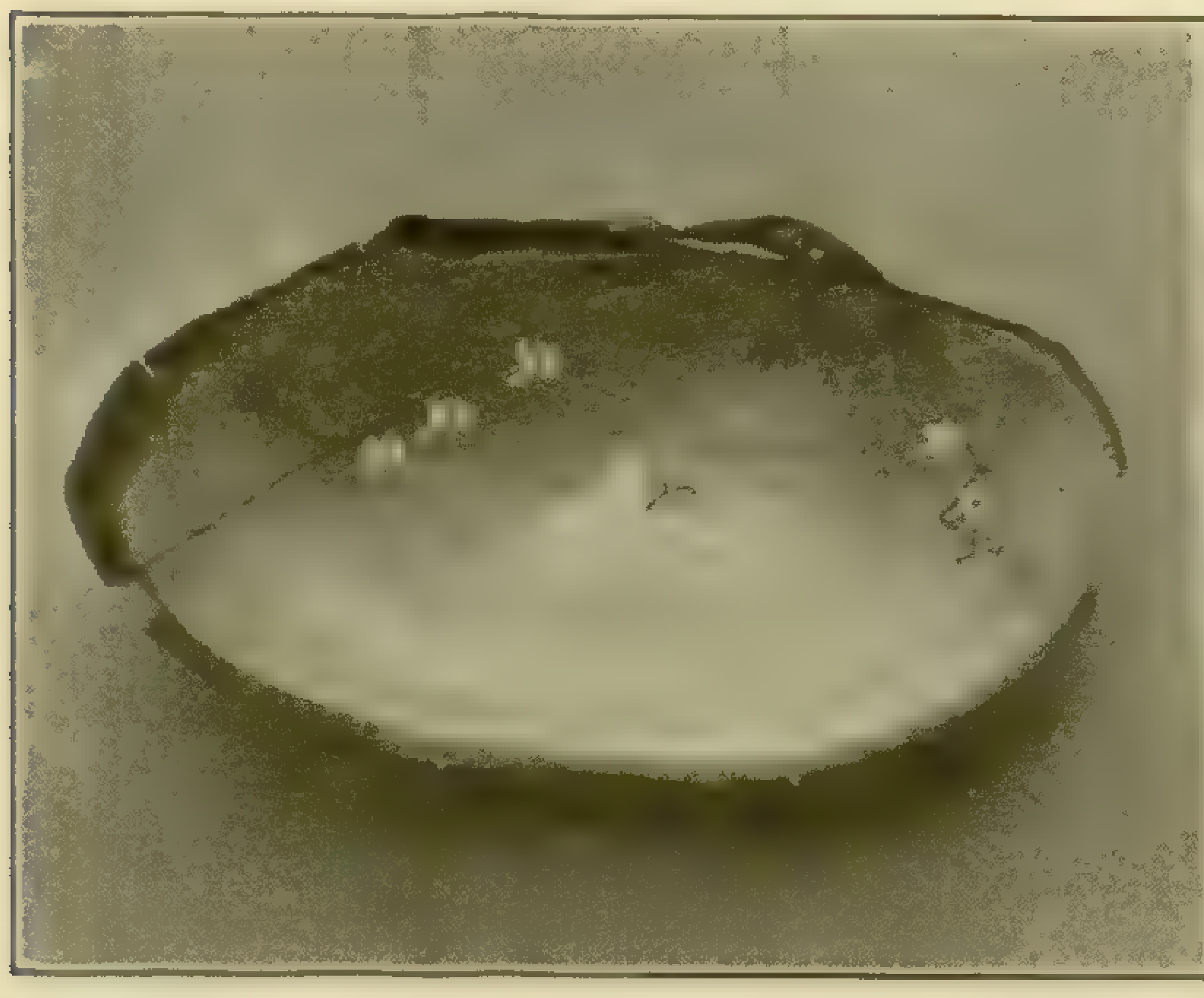
2. If not, how does it vary ?

I chose for this study the ratio,

$$\frac{\text{distance from the umbo to the muscle}}{\text{distance from the umbo to the shell margin}}.$$

In all the shells the separation of the anterior adductor from the anterior retractor is marked by a very distinct ridge, making a fine line which lies in the path of migration. The distance measured along this line on the curve of the shell, from the umbo

to the point where the outer boundary of the anterior adductor scar cuts the line, made the first term of the ratio (see x_1, x_2, etc., Figs. 1 and 3). The second term was the distance from the umbo along this line produced to its intersection with the shell



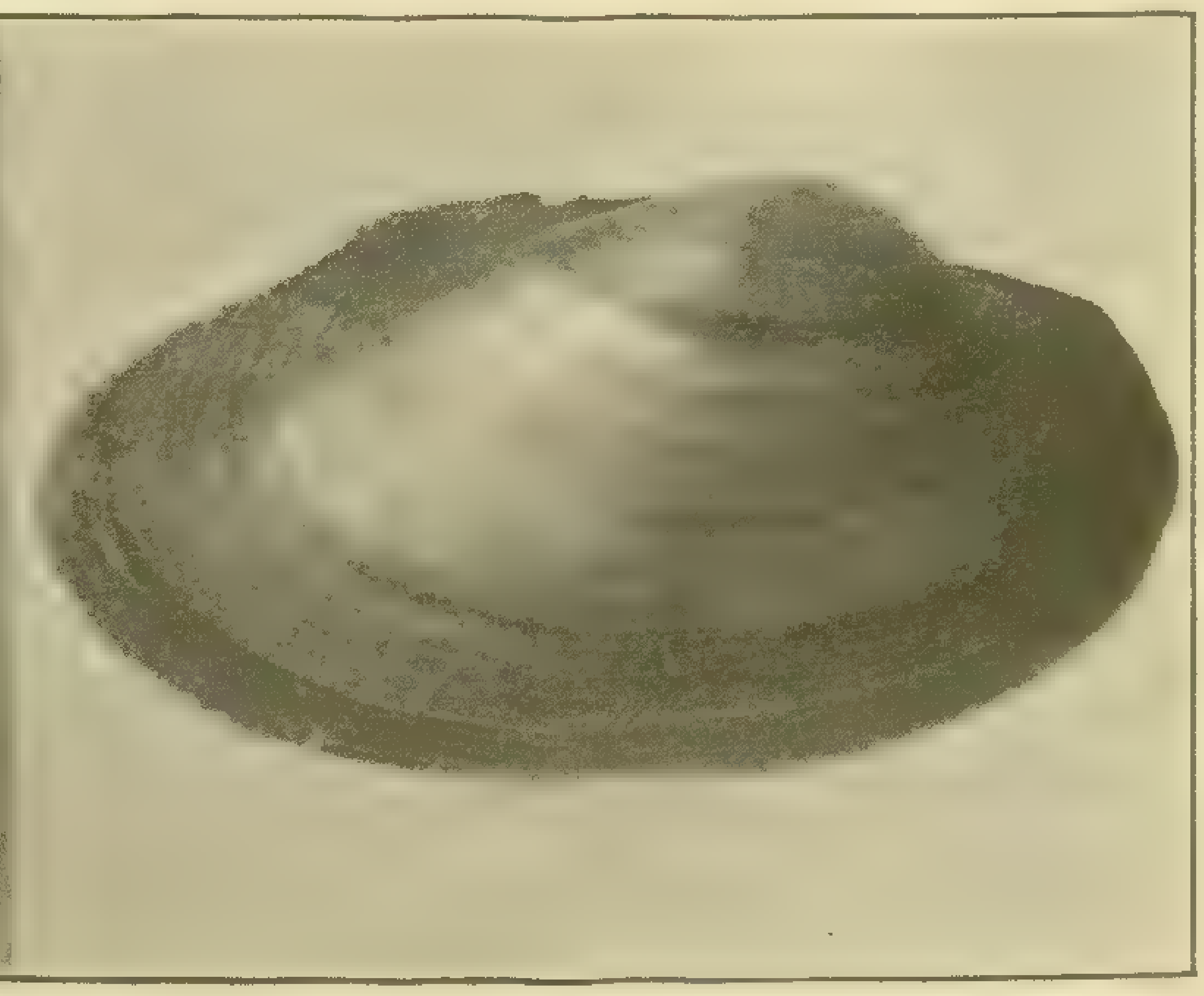
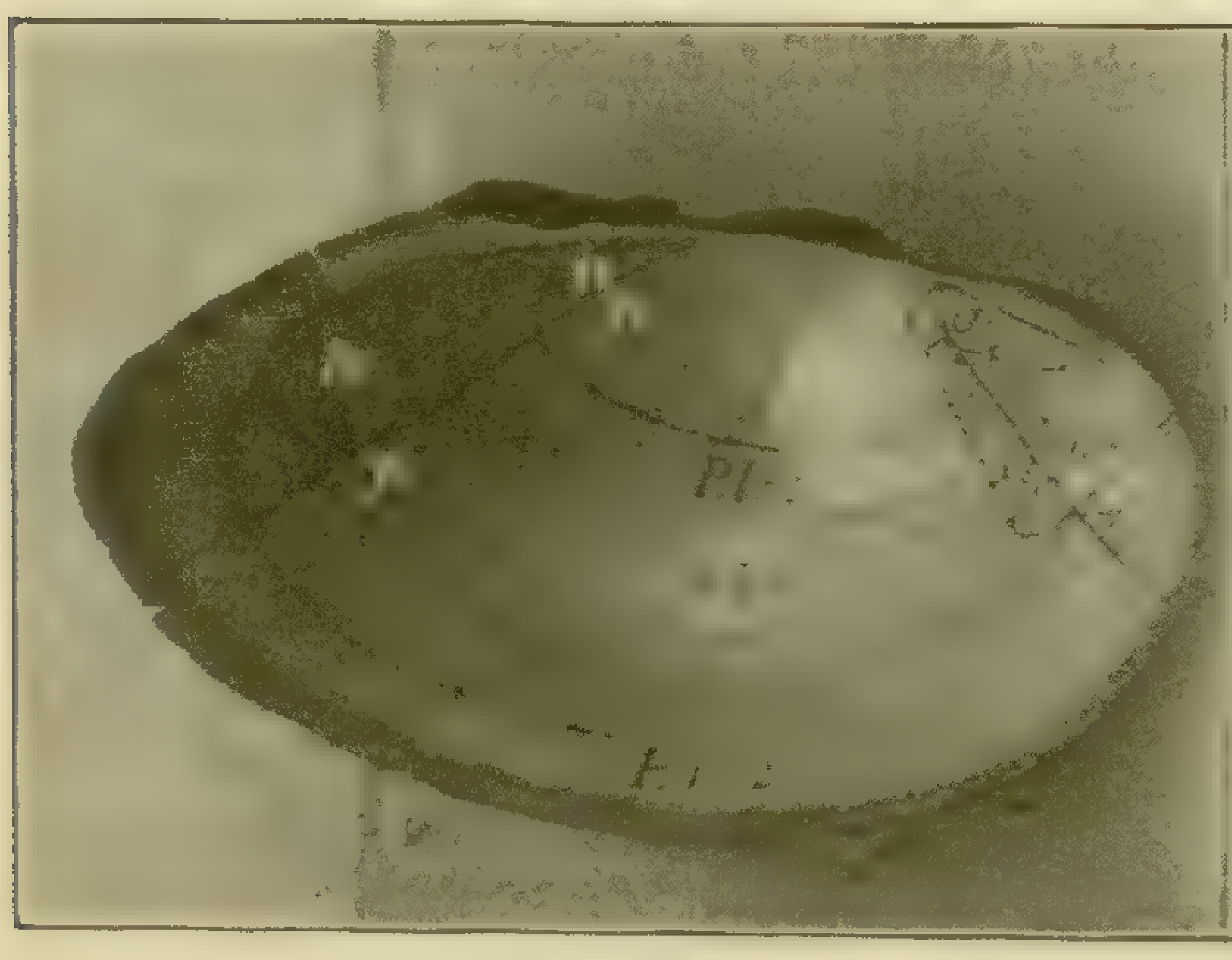


Fig. 1. Fig. 2.



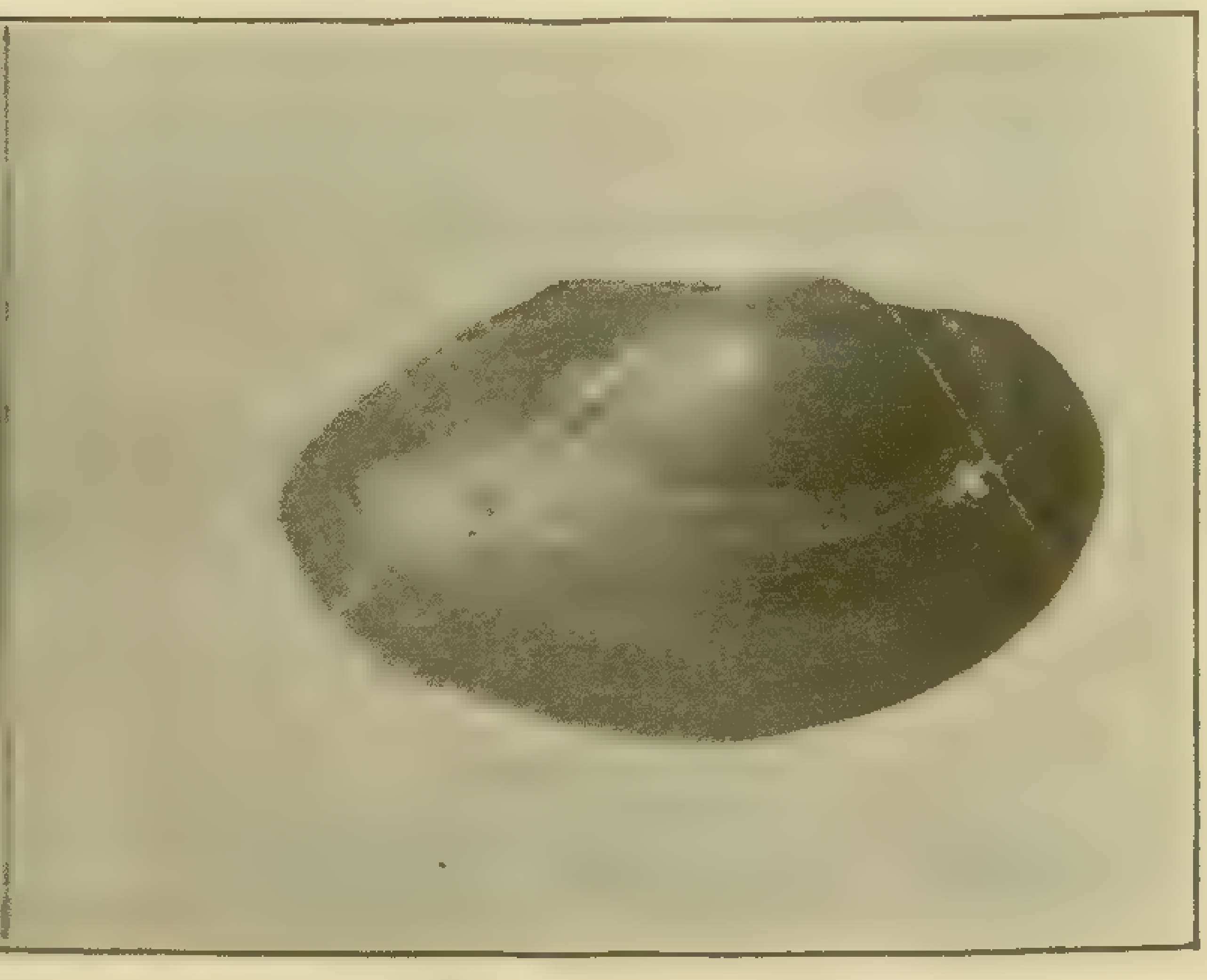


Fig. 3. Fig. 4.

Fig. 1. — Interior of a four-year-old shell, impressions emphasized by ink lines.

Fig. 2. — Exterior of a four-year-old shell.

Fig. 3. — Interior of a two-year-old shell.

Fig. 4. — Exterior of a two-year-old shell.

a_1, a_2, anterior adductor scars; p_1, p_2, posterior adductor scars; x_1, x_2, x_3, etc., points on ridge between anterior adductor and anterior retractor, fixed by its intersection with the adductor's outer margin; y_1, y_2, etc., points on ridge at anterior limit of posterior muscle impression at which adductor margin is tangent to the ridge.

margin. A similar ridge is formed at the anterior margin of the posterior adductor. The first term of the ratio for the posterior adductor is the distance from the umbo to the point where this line is tangent to the adductor scar (y_1, y_2, etc., Figs. 1 and 3). The second term is the distance measured

along this line produced, from the umbo to its point of intersection with the shell margin. The proportions then are:

$$\frac{\text{umbo to anterior adductor}}{\text{umbo to anterior margin}}, \text{ and } \frac{\text{umbo to posterior adductor}}{\text{umbo to posterior margin}}.$$

The umbo in this species comes to a sharp point, which was in no case eroded. It afforded a definite point from which to measure. The measurements were made along the outer surface of the shell. The shells were thin and quite transparent, so that lines and points marked on the inside were readily traced by a soft pencil on the outside by holding the shell to a strong light (Fig. 4). Most of the shells were four years old, a few three, and some two. (The exteriors of two- and four-year-old shells are given in the figures.) Measurements were made and the ratios calculated for two hundred and seventy anterior adductor scars, and for the same number of posterior adductor scars.

In order to plot a curve for these ratios, the following classes were taken for the anterior adductor:

Classes.	Frequencies.
.585 – .604	1
.605 – .624	8
.625 – .644	27
.645 – .664	38
.665 – .684	90
.685 – .704	64
.705 – .724	27
.725 – .744	13
.745 – .764	2
	270

The classes for the ratios of the posterior adductor are:

Classes.	Frequencies.
.575 – .594	1
.595 – .614	8
.615 – .634	25
.635 – .654	71
.655 – .674	96
.675 – .694	45
.695 – .714	19
.715 – .734	4
.735 – .754	1
	270

Different limits for the classes were selected in the seriation so as to give in each case the most nearly normal distribution of frequencies.

Laying off the frequency polygon by the method of rectangles gives Figs. 5 and 6, both curves of Type 4. The essential data for these curves are:

	ANTERIOR.	POSTERIOR.
A	.6783	.6613
v_1	.0033	–.0037
u_3	–.00000138	–.00000297
B_1	.00005	.041
B_2	74.47	1388.8
F	–142.94	–2771.47
α (skewness)	–.00028	–.022
σ (index of variability)	.0287 ±.00083	.0254 ±.00073

Discussion of results.

1. *The distance of the adductor muscle from the umbo*, measured along the line of migration, *varies considerably in its relation to the distance to the shell margin*, measured along the same line produced. The extreme ratios are .591 and .754. The measurements in the latter case are $\frac{49 \text{ mm.}}{65 \text{ mm.}}$. To produce the former proportion we should have to have 37.3 mm. instead of 49 mm., — a change of 11.7 mm., or nearly ¼ of the total measurements.

2. *While the range of variation* then *is comparatively large, yet the frequencies are well concentrated* at or near the mode. *In 93 per cent of the cases the position of the muscle would not vary 3 mm., in either direction from the mean position.*

3. *Roughly speaking*, we may say that *the muscle is situated two-thirds of the way from the umbo to the margin.* Accurately, the mean ratios are .6757 for the anterior muscle and .6608 for the posterior.

4. It was thought at the outset of the investigation that the results might indicate a difference in the rate of migration of the adductor muscles, one approaching the shell margin at a more rapid rate than the other. The negative skewness of both

curves, however, would indicate a tendency toward smaller ratios; that is, a decrease in the relative distances from the umbo to the muscle impression. This may mean that the muscles migrate constantly less rapidly than the margins grow. Since the skewness is least in the anterior adductor curve, the anterior adductor tends to move toward the margin at a more rapid

FIG. 5.

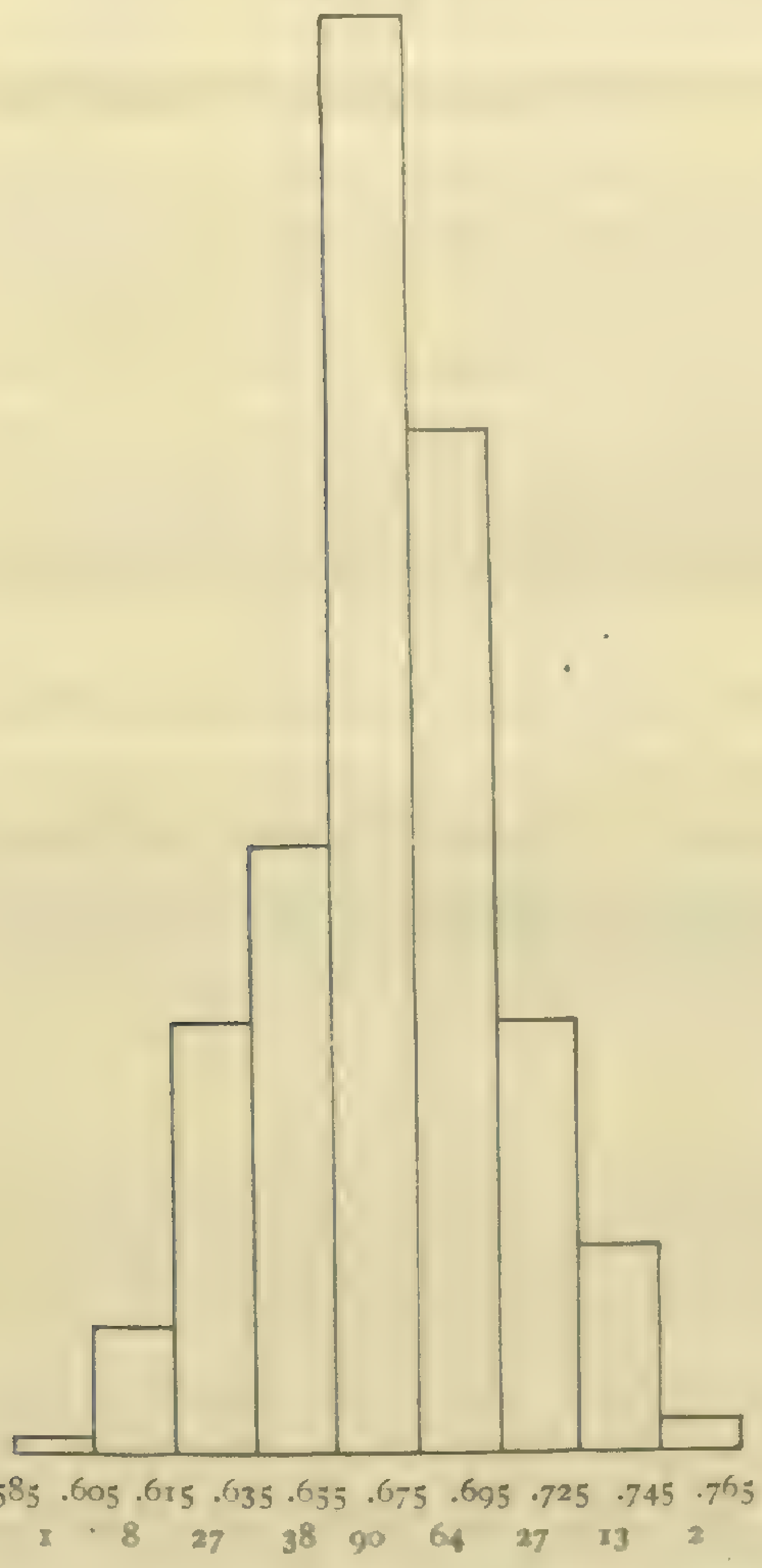


FIG. 6.

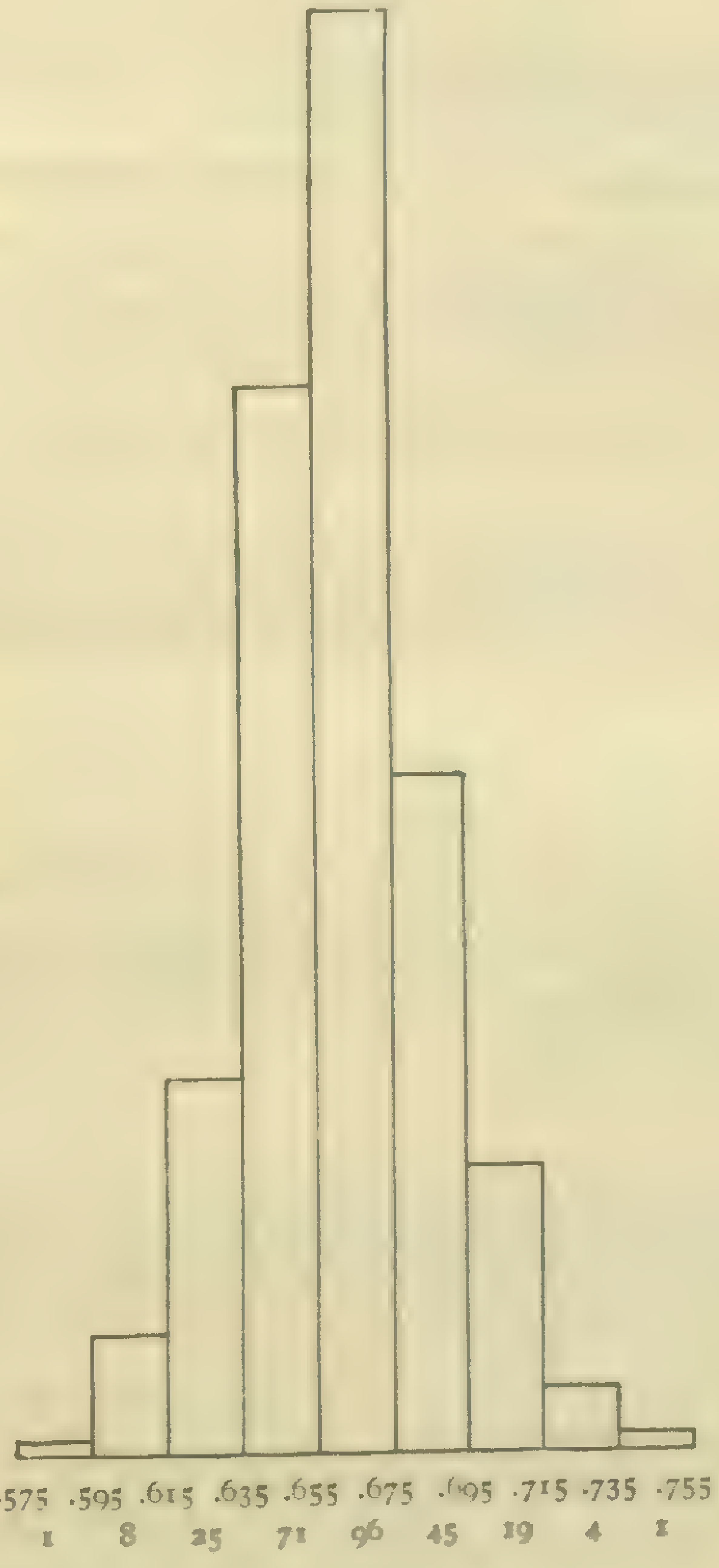


FIG. 5. — Frequency polygons for anterior adductor ratios.
FIG. 6. — Frequency polygons for posterior adductor ratios.

rate than the posterior, although there is a tendency in both to lag behind the rate of growth of the shell margin. The greater variability of the anterior muscle position would indicate that it is the muscle most concerned in the evolutionary process. However, variability and skewness are both so slight that the above conclusions must be tentative until

further evidence can be adduced. We seem to have in this form a species that is stable, rather than one that is in process of rapid evolution.

I am indebted to Dr. C. B. Davenport for valuable suggestions and assistance in carrying on this study.

Hull Biological Laboratory,
Chicago University.

NOTES AND LITERATURE.

ZOÖLOGY.

Temperature of Insects. — Professor Bachmetjew's[1] paper is one of those rare publications which is full of interest not only to the specialist in entomology but to biologists in general. The Russian author, with the equipment of the trained physicist, approaches a subject that has often been studied before, and after treating it in an exhaustive manner reaches new and important results, which would carry conviction in their very simplicity, even if they were not substantiated step by step by detailed tables of observations. The work of all previous investigators in determining the vital temperature of insects is briefly and critically reviewed as a preface to each of the main sections of the work.

In order to determine the temperatures, the insect was spitted through the thorax on a thermoelectric needle consisting of fused manganin and steel wires connected with a galvanometer. A detailed account of the somewhat complicated apparatus and the method of using it are given in an appendix (pp. 138–142). A number of different insects, mostly larger moths, butterflies, and beetles, both pupal and imaginal, were used in the experiments.

The first part of the work is devoted to a consideration of the body temperature of insects. In his earlier experiments, Bachmetjew came to the conclusion that the temperature of the insect body varies within very considerable limits, apparently without any serious consequences to the life of the animal. He found, moreover, that in resting insects the temperature is the same or very nearly the same as that of the surrounding air. Subsequent experiments, however, led him to conclude that this is true only under ordinary conditions of moisture, temperature, etc., since these factors, when abnormal, have a very pronounced effect on the body temperature. Under normal conditions, when the temperature of the atmosphere is raised, the temperature of the insect, though rising, lags at first more and more behind

[1] Bachmetjew, P. Temperaturverhältnisse bei Insekten. Experimentelle entomologische Studien vom physikalisch-chemischen Standpunkt aus. Bd. i, pp. 4–160. Leipzig, Wilhelm Engelmann, 1901.

that of the atmosphere, and only begins to approach atmospheric temperature just before partial heat paralysis of the wing muscles sets in. After death the temperature of the insect and the air are the same. But when the air is very damp the body temperature of the insect is higher than that of the air. This is explained as due to evaporation of the body fluids and to respiration, the former having a tendency to diminish, the latter to raise, the temperature of the insect. Bachmetjew predicts that the study of the dependence of the body temperature on that of the air, under different conditions of moisture, will ultimately enable us to determine the metabolism of these animals, and hence their vitality at different temperatures.

The influence of the activity of the insect on its body temperature, long since noted by Newport (1837) and others, is exhaustively studied by Bachmetjew. While a moth is moving its wings its body temperature keeps rising, but falls suddenly with the cessation of this movement. The insect was studied under three conditions: first, at the ordinary temperature of the room; second, at a higher temperature in the thermostat; third, at a lower temperature in a cold-air bath. Experiments conducted at room temperature show that the moth (Sphingid) is incapable of raising its own temperature higher than 38.5° C. by means of muscular movement. Fluttering of the wings does not produce as high a temperature as "humming." At about 38° C. the insect often suddenly changed from humming to fluttering, or rested completely. Bachmetjew interprets this change as due to partial heat paralysis of the muscles. It is a transitory phenomenon, which disappears with the sinking of the temperature during rest to that of the surrounding atmosphere. The temperature at which the wing muscles are paralyzed (in *Deilephila euphorbiæ*) increases with an increase of the temperature (at ordinary moisture) and reaches 45.5° C., after which the moth loses the power of humming. Complete, *i.e.*, no longer transitory, heat paralysis of these muscles supervenes at a body temperature of 49.7° C. In somewhat moister air this result does not set in till 53° C. is reached. In a single experiment on Deilephila at low atmospheric temperature the muscle paralysis also appeared, but at a lower temperature. At a body temperature of − 0.5° C. all movements ceased, fluttering began at 12° C., and humming not till 20° C. had been reached. It would seem, therefore, that the temperature of partial paralysis of the wing muscles is directly proportional to the body temperature of the insect, as is also the case for higher temperatures. According to Bachmetjew, these effects of partial paralysis play a great rôle in the production

of color aberrations in butterflies. He also suggests that further study of these effects may explain why so many moths are nocturnal, while the butterflies are diurnal. Some experiments on the influence of respiration showed that Deilephila at 29.4° C. atmospheric temperature could raise its body temperature through at least 3° C. by means of breathing alone.

The second and more important portion of Bachmetjew's paper deals with the vital extremes of temperature. It is divided into two sections, one dealing with the maximum, the other with the minimum temperature. The vital maximum is the highest temperature at which an insect is able to live. Experiments on *Saturnia pyri* showed that the insect becomes very restless at a temperature of about 39° C. and dies when the body reaches a temperature of 46° C. This is also very near the lethal temperature for plants (Sachs and Schultze). This lethal temperature, however, depends on a number of factors. In general, it may be said that if the insect at high temperature first, has not been exhausted, *i.e.*, has been artificially fed; second, is not desiccated, *i.e.*, is in a sufficiently moist atmosphere; and third, presents the same conductivity to heat and the same body size for a given species. — its life will depend only on the coagulation or non-coagulation of its body fluids. Hence, the vital maximum is only another expression for the coagulation point of the body fluids. And if one knew the amount of water in the insect's albumins, especially of those albumins essential to life, the question of the vital maximum would resolve itself merely into a determination of the amount of water.

Bachmetjew's study of the vital minimum, *i.e.*, the lowest temperature at which an insect can live, brought out some startling results. He found from experiments on a great number of insects that different species died at very different temperatures. But his most interesting results refer to the critical point, which is the temperature to which the fluids of the insect may be undercooled before they begin to congeal and then suddenly rise in temperature till the normal congealing point is reached. Bachmetjew points out the resemblance of this phenomenon to the well-known undercooling of water, which can be cooled to − 25° C. without freezing, but at once rises to 0° C. to freeze. Bachmetjew discovered the undercooling of the body fluids of insects by accident in an experiment on *Saturnia pyri* ♀. The insect was cooled to − 9.4° C., whereupon within a minute's time the temperature bounded up to − 1.4° C., the normal congealing point of the body fluids, and then remained constant for

eleven minutes. In this case the critical point is $-9.4°$ C., and $-1.4°$ C. is the normal congealing point. This insect revived within an hour after the experiment, and laid eggs on the following day. From this Bachmetjew concludes that the mere congealing of the body fluids is not lethal. In a second experiment a moth of the same species showed a critical point of $-11.6°$ C. (4.25 P.M.), whereupon the temperature rose at once to $-1.1°$ C. The insect was kept in the cold, the temperature of its body again sinking to $-15.6°$. At 6.15 P.M. it was removed to the temperature of the room, but could not be revived. It follows that the insect dies if its body is still further cooled after the rebound (the limits being not necessarily higher than $-2.5°$ C. nor lower than $-15.6°$ C.), or, as a general rule, it may be stated that the insect dies if its temperature be again reduced to about the point from which it rebounded. Further experimentation on this interesting subject led to the following general conclusions here briefly transcribed. The extreme degrees of undercooling of the fluids differ in different insects, and these extremes occur at nearly the same rate of cooling. The critical point, so far as its absolute minimum is concerned, is greater in pupæ than in imaginal moths and butterflies, whereas the maximum differs in pupæ and imagines. Owing to lack of material, the behavior of the larvæ could not be determined. With respect to sex, the degree of undercooling of the fluids in normal specimens is lower in the males than in the females. This is also the case after brief fasting; after protracted fasting, however, the degree of undercooling is lower in the males, but finally becomes the same in both sexes. On the other hand, the normal congealing point of the fluids is lower in the females than in the males. After fasting, it is the same in both sexes; but after protracted fasting, the relation is again reversed. Further investigation of this question showed that the insect juices have a lower critical point when the insect is fasting, but so far as its absolute magnitude is concerned, it diminishes on continued starvation. Repetition of undercooling gave the following results: On freezing a second time strong Lepidoptera exhibit a much greater degree of undercooling than on the first freezing; on being frozen a third time the fluids show almost no undercooling. This is also shown by weak Lepidoptera on the second cooling. Bachmetjew also studied the influence of the fluid coefficient on undercooling. If M be taken as the total weight of the living insect, and P its weight after drying on a water bath for a long time at a temperature of 115° C., $M-P$

would represent the weight of the fluids which leave the body on evaporation at this temperature. The relation

$$\frac{M-P}{M}=q$$

is known as the fluid coefficient and signifies the percentage of fluids in a unit of weight of the living insect body. Experiment shows that the smaller the fluid coefficient the lower lies the normal congealing point of the fluids. The critical point is also influenced by the fluid coefficient, but this influence cannot be stated in general terms till the composition of the fluids has been further studied. Time also influences the critical point. If the temperature (t) to which the insect is undercooled coincides at the same rate of cooling with the critical point (K_1), the juices at once begin to congeal (*i.e.*, time $= o$); but if t does not coincide with K_1, the congealing of the fluids is delayed in proportion to this difference ($K_1 - t$).

Undoubtedly Bachmetjew's results are of a far-reaching character and will ultimately form the basis for important work along theoretical lines in physiology, and for practical applications of great moment (in economic entomology, *e.g.* !), for they throw light on the geographical and climatic distribution of organisms, the resistance of animals and plants to cold and heat, and the problems of anabiosis. That Bachmetjew himself is very sanguine concerning the results that may ultimately flow from his work is apparent when he says. "Es eröffnet sich somit ein ganz neues Gebiet für die Forscher, und wer weiss, ob die Zeit nicht nahe ist, wo man den märchenhaften hundertjährigen Schlaf auch bei Menschen künstlich hervorrufen könnte ! Die Insekten wenigstens bieten die Möglichkeit dazu."

W. M. W.

An Important Paper on Phoridæ. — Theodor Becker, of Liegnitz, Prussia, has recently published a work[1] of 100 pages, with five plates, on the family Phoridæ, which deserves notice among zoölogists in general because it is one of the finest pieces of systematic work that has been published on the Diptera.

The family Phoridæ includes only small species, generally from two to four millimeters in length, which do not offer to the observer with a hand lens a satisfactory series of specific characters. The genus Phora was early described and generally recognized from its

[1] *Abhandlungen der k. k. zool.-botan. Gesellschaft in Wien*, Bd. i, Heft 1, 1901.

peculiar venation; this led to the description of a large number of species by the earlier dipterists, among them Meigen, Macquart, Zetterstedt, Bohemann, Haliday, Rondani, and Egger, the types of which ultimately found lodgment in various public museums of Europe. Most, if not all, of these describers based their species chiefly on size and color, having but little comprehension of the real specific distinctions. When they came to identifying each other's descriptions, confusion was worse confounded, and down to the present time it has been impossible to get the family, which is mostly comprised in the single genus, into intelligible shape.

Mr. Becker secured for study the material contained in twelve public museums of Europe, including all the types now in existence of the earlier descriptions, with a few exceptions. He not only made a thorough study of all these collections, but he has published a full report in this work on the named species and types in each, thus putting the old species in a perfectly clear light and preventing future disputes over alleged types and misnamed species in these collections.

In addition to this material and that in his own collection, Mr. Becker was able to study the collections of some eight dipterists of the present generation, so that his work may fairly be termed exhaustive.

Sixty-five European species of the genus Phora are described, of which twenty-two are new. The remainder of the family, as represented in Europe, consists of Trineura, three species; Conicera, two species; Gymnophora and Metopina, one each.

The arrangement of the paper is admirable, and includes the following sections: table of genera of the world; structure and characters of the genus Phora; analytical table of species; description of species; enumeration of the named species in each of the type collections examined, with the proper status of each specimen; a brief division on biology; other European genera and species; extra-European genera, with their species; index of European species, including synonyms; list of accepted European species; list of extra-European described species in the family, with references; explanation of plates, and table of contents. This will give an idea of the completeness of the work.

The characters used are largely those of the bristles, the "chætotaxy" of recent writers; without the use of these bristles it would be impossible to write an intelligible description of many of the species. There is no family of flies in which it is more essential.

One might wish to see a more extended notice of the biology of the Phoridæ, but as long as we have not yet nearly reached the point where we can extend our classification to the larval stages, it is not improper to allow the natural history of the species to form a separate subject.

This paper will be of great advantage to American workers, as it will enable them to ascertain how far our species are identical with the European, Becker's descriptions being so exact that it will be possible to determine without comparison of specimens, I should judge.

To take up a family that is in a state of chaos and transform it into order and beauty by a single publication is a great achievement, and one not accomplished without long and arduous study. Mr. Becker has produced a monumental work, easily the greatest he has yet attempted, and one which may well be taken as a model by younger entomologists.

J. M. A.

Habits of Insects. — An English rendering of the first volume of Fabre's delightful *Souvenirs entomologiques. Études sur l'instinct et les mœurs des insectes*, though with an exceptionable title and an overburdened title-page,[1] is to be heartily welcomed. It makes accessible to a larger circle some of the early work of a keen inquirer into the faculties of insects. Well and favorably known since 1879, Fabre's observations have instigated similar and successful work elsewhere, and it is only from the philosophical side, Fabre being a rigid opponent to any form of evolution, that his writings are open to hostile criticism.

The volume under notice begins with an account of the habits and life history of *Scarabæus sacer*, and is devoted almost wholly to the higher Hymenoptera, though incidental observations concerning other insects are given.

With due allowance for the many difficulties, the translation is fairly well done. Editorially the volume cannot be considered as altogether satisfactory; the supervision of an entomologist should have precluded the translation of *grillon* indifferently as "cicada," "cricket," or "grasshopper," the almost universal use of "feet"

[1] Fabre, J. H. *Insect Life. Souvenirs of a Naturalist.* Translated from the French by the author of *Mademoiselle Mori.* With a preface by David Sharp. Edited by F. Merrifield. With illustrations by M. Prendergast Parker. London, Macmillan & Co.; New York, The Macmillan Company, 1901. xii + 320 pp., 16 pls.

(*pattes*) for "legs," and the frequent confusion between genus and family.

Footnotes recording similar work or opposite conclusions would have been valuable, and the lack of an index is especially regrettable.

S. H.

BOTANY.

The Rhodomelaceæ. — Originally planned as one of the series of monographs of the marine organisms of the bay of Naples, the author[1] of this work has extended its scope until now it covers the entire family of the Rhodomelaceæ, as represented in all waters. Of its large quarto pages 109 are given to the general part, covering the anatomical development of the stem, the morphology of the vegetative organs, and the reproductive organs; 588 pages are given to the special part, with detailed studies of all the species found in the Neapolitan region, and of all other species authentic specimens of which were accessible to the author; 248 species are elaborately treated in this part. The third part, "Systematic Results," 34 pages, includes notes on phylogeny, on the relation of the Rhodomelaceæ to other families, and a synoptical view, practically a key to the genera of the Rhodomelaceæ, giving under each genus the names, with descriptions, of the species described in the second part, and of such other species as the author had reason to consider sufficiently studied to leave no doubt of their position under his arrangement. The large genera Laurencia and Polysiphonia are excepted from this full treatment, only a portion of the species being mentioned, about which the many other species can be grouped; even with this reduction, 320 species are given in this third part.

A monograph of this character, from the hands of the one person competent for the task, is an important event, and the care and thoroughness with which it is done are remarkable. The author undertook the task in 1878, and some of the plates were printed in 1885; after all, this long stretch of time seems none too much for the enormous amount of work involved. What the future may

[1] Falkenberg, R. *Flora und Fauna des Golfes von Neapel.* 26. Monographie. Die Rhodomelaceen. Herausgegeben von der Zoologischen Station zu Neapel. Berlin, 1901. xvi + 754 pp., 24 pls.

bring, no one can tell, but it is difficult to imagine anything that will affect, except in details, so logical and well-grounded a classification as this.

In 1889 Schmitz published his *Systematische Uebersicht der bisher bekannten Gattungen der Florideen*, and in 1897 "The Rhodophyceæ," in Engler and Prantl, *Die Natürlichen Pflanzenfamilien*, was from the manuscript left by Schmitz at his death: in both of these the Rhodomelaceæ were based on Falkenberg's studies, but in both changes were made, with Falkenberg's consent, from his original plan, to conform with Schmitz's general system. In the present work no such change was needed.

The nomenclature of the present work, as compared with J. G. Agardh's, the former standard, shows considerable change. Few new species have been described, and consolidation of existing species has, apparently, at least equaled their division: but the larger genera have been split up, so that the number of new binomials is quite considerable. The increased number of genera seems the result of a logical employment of certain definite characters throughout the family, — monopodial or sympodial growth, radial or dorsiventral character of the frond, endogenous or exogenous character of the regularly distributed branches, presence or absence of "leaves" in addition to the branches, number of pericentral cells, their persistence unchanged or ultimate division, etc. The sexual organs are practically uniform throughout the family, and where the arrangement of the tetraspores appears to offer distinctive characters, it is probably due to the structure of the branches in which they are formed. In conformity with the general algological practice, no attempt has been made to substitute dead and forgotten generic names for long-established ones of later date, but in some cases the older names are given as synonyms: this last may be quite a convenience for persons wishing to attach their names to new binomials, though not familiar with the plants in question.

Many American forms are studied and figured, representatives occurring of the new genera Brongniartella, Bryocladia, Dasyopsis, Falkenbergia, Herposiphonia, Heterosiphonia, Lophocladia, Lophosiphonia, Ophidocladus, Pterosiphonia and Wrightiella; genera, that is, that may be considered as new, for although most of them appear in Schmitz's papers previously mentioned, they now for the first time are given with full characters and list of species included.

Rhodomela floccosa of our northwest coast is transferred to Odonthalia, a very satisfactory place for the luxuriant, pinnately branched

plant of the northern Pacific; but there are other forms passing under this name of quite different habit, for which a place must be found somewhere else. *Polysiphonia bipinnata* Post. and Rupr. is referred to Pterosiphonia, but with exclusion of *Polysiphonia californica* Harv., hitherto generally regarded as a synonym. This transfer being based on original material is undoubtedly decisive, but, as in the case of *Rhodomela floccosa*, we are left with a long series of forms, some of which will not go into Pterosiphonia. It may be that they can be included in *Polysiphonia californica*, but more study is needed. *Chondria baileyana* Harv. and *C. sedifolia* Harv. are restored to specific rank, but in actual collecting it is not easy to draw the line between the former and what is called *C. tenuissima* on the northeast coast, and between the latter and *C. dasyphylla*.

In regard to the Baltic forms of *Polysiphonia violacea* (Roth) Grev., which Reinke considered identical with *P. harveyi* Bailey and *P. olneyi* Harv. of the American coast, denying autonymy to these two species, the author considers Reinke's identification an error, Harvey's types being amply distinct from the Baltic forms. This is a relief to American algologists, who were about ready, if *P. violacea* and *P. harveyi* were united, to accept one name for all four-tubed Polysiphonias whatever. The union under *Rhodomela subfusca* (Woodw.) Ag. of such various forms as *R. lycopodioides* (L.) Ag., *R. virgata* Kjellm., and *R. rochei* Harv. is possible only by giving an extreme range in habit and mode of fruiting. It still seems as if *R. subfusca*, taken in so broad a sense, must be an aggregate, to be divided sooner or later.

A work as thoroughgoing as the present, and starting from the foundations, must continually reach conclusions differing from those of previous writers, and the author states these divergences and contradictions with great frankness; not ill-naturedly, but sometimes apparently with a little impatience with errors which could have been avoided by a little more careful observation. Practically every one who has written on or referred to the Rhodomelaceæ comes in for correction sooner or later, most of all the late Professor Agardh, both as the most conspicuous writer and because in spite of, perhaps in consequence of, his remarkable intuitional perception of systematic relations among the algæ, he was never a careful and punctilious student of the development of their structure, and it is upon the development, rather than on the mature structure, that the classification of the present work is based. As compared with the elaborate synonymy of Bornet and Flahault's

monograph of the heterocysted Nostochaceæ, the synonymy here is quite meager; those who are interested in the *ganzen Ballast veralteter Namen aus jener Zeit* are referred to Agardh's, Kutzing's, and Harvey's works. References to standard plates are abundant, but there are practically no references to published exsiccatæ, which is often unfortunate; a plate can tell only what the artist saw, or even only what he chose to represent; the plant itself, if in proper condition, is ready to answer questions that never occurred to the artist or the author. The plates in the present work give an instance of this: when a figure is intended to show the position of certain cells, it shows that with the utmost distinctness, but usually nothing more; no indications of thickness of cell walls, character of chromatophores, etc.; where some other character is under consideration, that is given the prominence, to the exclusion or subordination of all others. The plates, however, tell admirably what they undertake to tell; if we were told also where we could find the plant itself, nothing more could be asked. But some remarks by the author as to specimens which belong to several distinct species and appear as autograph authentic specimens of a single species may account for a reluctance to give exsiccatæ numbers.

The work is written in a clear and comprehensible style, and now and then contains a graphic expression, which, if not necessary for scientific value, certainly does not detract from it. It would seem that any student, with even a fair knowledge of German, could use the work readily. The ordinary American student, however, will be more likely to borrow the copy of some well-to-do friend than to own one, the price being 120 marks.

Californian Nitophylla.[1] — In the historical sketch with which this paper opens, the first reference to Californian Nitophylla is given as "W. H. Harvey, 1858, Pt. II, p. 104, Suppl., p. 128." This is misleading, as Part II of the *Nereis* was published in 1853; Part III, with the supplement, in 1858. Thus the history of Nitophyllum in California dates back five years earlier than given by the author. The latest reference is in 1898, when J. G. Agardh published Vol. III, Part III, of the *Epicrisis* (noticed in the *American Naturalist* for June, 1899), giving fourteen species for the west coast of America. Mr. Nott's careful study of living and dried material, from all parts of the coast, shows that six of these must be

[1] Nott, Charles Palmer. Nitophylla of California, Description and Distribution, *Proc. Cal. Acad. Sci.*, Ser. 3, Botany, vol. ii (1901). 62 pp., 9 pls.

considered merely forms of the other eight. A new species, *N. corallinarum*, is added, together with the New Zealand species, *N. harveyanum*, making the final list ten.

The genus has a world-wide distribution and includes many handsome species, with large, delicate, more or less veined membranes of various shades of red. The Californian species are not inferior to others in size and beauty, and the present paper gives a careful study of them, with ample description, full synonymy and references. The considerable variation occurring in some species is noted as accounting for the new species proposed by Agardh; unless one had a large series of forms of *N. ruprechtianum*, for instance, it would be perfectly natural to describe extreme forms as distinct species.

The plates illustrating this paper are by a photolithographic process, and, while showing fairly well the habit of the broader membraned species, are less satisfactory with the other species. Dependence in determining must be had on the text and the references to exsiccatæ.

Alaskan Algæ. — This paper[1] gives quite an addition to our knowledge of the marine and fresh-water flora of our northwest coast, nearly half of the marine and more than half the fresh-water species being new to Alaska. The really northern flora of the west coast begins at Puget Sound, practically all the species from this point north being distinctively northern in character, though some of them extend south to central California. Of the red and brown algæ, 55 are circumpolar or found in the north Atlantic, 49 peculiar to the Pacific. In the table, p. 394, these 49 species are in a column headed "Peculiar to the Pacific Coast of North America." As this column includes such Asiatic species as *Cystophyllum lepidium* and *Odonthalia kamtschatica*, and such south Pacific species as *Macrocystis pyrifera*, the heading is very misleading. If it were intended to say that they were not found on any coast of North America except the Pacific, it would be true, but that is not the natural meaning of the words. Nine new species are described and figured by Mr. Saunders, *Streblonema pacificum*, *S. irregulare*, *S. minutissimum*, *Dermocarpa fucicola*, *Homœostroma lobatum*, *Myelophycus intestinalis*, *Coilodesme linearis*, *Mesogloia simplex*, and *Alaria fragilis*; also *Pleurophycus gardneri* Setchell and Saunders; a few less familiar forms already described are figured, a plate is given of a

[1] Saunders, De Alton. Papers from the Harriman Alaska Expedition. XXV. The Algæ. *Proc. Wash. Acad. Sci.*, vol. iii (Nov. 15, 1901), pp. 391–486, Pls. XLIII–LXII.

Liebmannia (?) but without specific name, and some 60 species of desmids are figured on Plates XLIII and XLIV.

Nereocystis priapus (Gmelin) Saunders takes the place of *N. Luetkeanus* Mert., universally accepted since its publication in 1829. While it is probable that Gmelin's plate of *Ulva priapus*, published in 1768, represents a fragment of a frond of this species, no one before Mr. Saunders has proposed the change, though Gmelin's name has often been mentioned as a possible synonym.

Some curious phrases occur: p. 426, *Alaria lanceolata* is said to be "easily recognized by the tufts of long cryptostomata"; p. 434, *Iridæa membranacea* J. Ag., "To this species Dr. Farlow has very questionably referred," etc. The context shows that "questionably" is used in the sense of "doubtfully," and the word is used in apparently the same sense (p. 440) in regard to *Gloiosiphonia californica*. On p. 438 there are notes on the "perithecia" of two species of Odonthalia. There is a curious tendency to give specific names the feminine ending in all genera whose names end in *a*. In the table, p. 394, this is consistently carried out, — *Streblonema pacifica*, *Homœostroma undulata*, etc. In the descriptive text, later, some are changed to neuter, others continue feminine. Possibly these are only instances of the misprints which abound in the names throughout the paper, due in part to scanty time allowed for correction of proof, and perhaps to volunteered corrections by some other than the author. See p. 414, *Cladophora arctica* for *C. arcta*.

The plates are clearly drawn and printed, the descriptions of new species are fairly complete, and, as a whole, the paper is a valuable addition to our knowledge of the plants of our northwestern possessions.

Agardh's Algæ.[1] — In the notice of Part III of this work, in the *American Naturalist* for June, 1899, attention was called to the long time, the greater part of the nineteenth century, of Agardh's work in this field, and the hope was expressed that the paper under consideration might not be the last. One more part has been issued, but only half of the proof had been read by the author at the time of his death. In this part there is a rearrangement of the genus Gracilaria, notes on some other genera, and an article, "On the Principles of Classification to be adopted for the Florideæ." This he considered as of great importance, as a final statement of his

[1] *Species, Genera et Ordines Algarum.* Auctore Jacobo Georgio Agardh. Vol. iii, pars iv (Lund, 1901), pp. 149.

views, and something of a protest against the Schmitzian principles. At eighty years of age one does not readily give up the principles upon which one's life work has been based, but every system, when it has done its work, must give place to something else, at least until our knowledge has advanced far beyond its present state.

But the Agardhian system has been very useful in its day, and with the death of its author we lose one of the most conspicuous figures in the botanical field. Born in 1813, the son of C. A. Agardh, the foremost algologist of his time, his publications range from 1836 to 1901, the first part of the work whose last part we have just noticed appearing in 1848. His main characteristics were his quick grasp of a situation, however complicated; his unerring instinct for really important characters; his prompt recognition of true affinities. With this type of mind, the toilsome, plodding investigation required by modern conditions was not to be expected; but it was the type of mind needed to bring order out of the chaos of conflicting schemes prevailing at the time, and to arrange the great numbers of new forms coming to light in all parts of the world.

In person, as in mind, Agardh might be classed with the Norse giants. Tall, well formed, athletic, dignified, serenely confident of his position, he was a benevolent, gracious potentate of botany. Very liberal in the distribution of specimens, he yet, like all royal personages, held some in favor and some in disfavor, and more than one private student in America has received from him a finer set of his algæ than can be found in Berlin, or some other great botanical centers. The name Agardhia having been used in honor of his father, Agardhiella, a genus of red algæ with one handsome species on our Atlantic coast and one on the Pacific coast commemorates him, while many species bear his name. The red algæ were his special field, and in spite of all of the modern advances it will be long before his works cease to be the place to which one will naturally first turn when studying these plants.

QUARTERLY RECORD OF GIFTS, APPOINTMENTS, RETIREMENTS, AND DEATHS.

EDUCATIONAL GIFTS.

Allegheny College, $200,000, from various donors.

Amherst College, $15,000, from an anonymous donor; $1000, from Warren F. Draper.

Athol (Mass.) Public Library, $15,000, from Andrew Carnegie.

Atlantic, Iowa, $12,500, from Andrew Carnegie, for a public library.

Baraboo, Wis., $12,000, from Andrew Carnegie, for a public library.

Barnard College, $250,000, from John D. Rockefeller; $250,000, from other sources.

Beatrice, Neb., $20,000, from Andrew Carnegie, for a public library.

Benton Harbor, Mich., $15,000, from Andrew Carnegie, for a public library.

Blue Island, Ill., $15,000, from Andrew Carnegie, for a public library.

Boston Public Library, $100,000, from the estate of the late Nathan Haskell Dole.

Bozeman, Mont., $15,000, from Andrew Carnegie, for a public library.

Brazil, Ind., $20,000, from Andrew Carnegie, for a public library.

Brown University, a conditional gift of $75,000, from John D. Rockefeller; $100,000 and the residuary estate (which may amount to $500,000) by the will of Geo. L. Littlefield.

Buchtel College, $20,000, from several donors.

Carroll College (Wis.), $20,000, from Ralph Vorhees.

Cedar Falls, Iowa, $15,000, from Andrew Carnegie, for a public library.

Charlotte, Mich., $10,000, from Andrew Carnegie, for a public library.

Chicago Heights, Ill., $10,000, from Andrew Carnegie, for a public library.

Clark University, $100,000, by the will of Jacob Wheelock.

Columbia University, $3000, from Adolph Lewissohn; $100,000, from an anonymous donor; $50,000, by the will of Mrs. Lila Currier; $11,000, from an anonymous donor.

Cooper Union (N.Y.), $300,000 each, from Andrew Carnegie and the descendants of Peter Cooper; an anonymous gift of $250,000.

Denison, Iowa, $10,000, from Andrew Carnegie, for a public library.

Denver Public Library, $200,000, from Andrew Carnegie.

Fulton, N.Y., $15,000, from Andrew Carnegie, for a public library.

Greensburg, Md., $15,000, from Andrew Carnegie, for a public library.

Hamilton College, $50,000, from the alumni.

Hampton, Iowa, $10,000, from Andrew Carnegie, for a public library.

Harvard Medical School, $1,000,000, from John D. Rockefeller; $250,000, from Mrs. C. P. Huntington; $100,000, from James Stillman; $471,225, from others.

Harvard University, $450,000, by the will of George Smith; $100,000, by the will of Robert C. Billings; $100,000, by the will of Jacob Wheelock.

Haverford College, $50,000, from Mrs. Charles Roberts.

Iowa City, Iowa, $25,000, from Andrew Carnegie, for a public library.

Las Vegas, N.M., $10,000, from Andrew Carnegie, for a public library.

Lehigh University, $5000, from Warren A. Wilbur.

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Maquoketa, Iowa, $10,000, from Andrew Carnegie, for a public library.

Massachusetts Institute of Technology, $100,000, by the will of Robert C. Billings.

Melrose (Mass.) Public Library, $25,000, from Andrew Carnegie.

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New York Botanical Garden, $5000, from Mrs. George Whitfield Collett.

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Rochester Academy of Medicine, $5000, from Charles T. Ham, for medical research.

Teacher's College, Columbia University, $250,000, from an anonymous donor.

Tipton, Ind., $10,000, from Andrew Carnegie, for a public library.

University of Chicago, $1,250,000, from John D. Rockefeller.

University of Pennsylvania, $2500, from William Ivins; $2500, from James Hay; $5000, from Ralph C. Stewart; land valued at $12,000, from Gen. Isaac C. Wistar; anonymous gifts of $15,000.

University of Wooster (Ohio), a conditional gift of $100,000, from Dr. D. K. Pearson; $5000, from the directors of the Pennsylvania Railroad; $100,000, from Andrew Carnegie; $50,000, from L. H. Severance.

Vassar College, a conditional gift of $200,000, from John D. Rockefeller.

Washington (Mo.) University, $25,000, by the will of Geo. E. Leighton; $20,000, by the will of William E. Huse.

Washington and Lee University, $5000, from John D. Rockefeller; $30,000, by the will of Mrs. S. P. Lees.

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Syracuse University, $100,000, from John D. Rockefeller.

Yale University, $5000, from the class of 1876: $100,000, by the will of Mrs. Lila Currier.

Yankton (S.D.) Public Library, $10,000, from Andrew Carnegie.

APPOINTMENTS.

Dr. A. F. Adams, assistant in histology in the University of Toronto. — Dr. Leon Asher, professor of physiology in the university at Bern. — Prof. Saverio Belli of Turin, professor of botany in the university at Cagliari. — Dr. Max Belowsky, custodian of the Mineralogical Petrological Institute in Berlin. — Dr. Max Bleibtreu, professor of physiology in the University at Bonn. — Dr. Georg Böhn, honorary professor of geology in the university at Freiburg i. B. — Dr. G. Brandes of Halle, scientific director of the zoölogical gardens there. — Dr. H. C. Bumpus, director of the American Museum of Natural History. — Dr. Wesley R. Coe, assistant professor of comparative anatomy in Yale University. — Dr. John M. Coulter, professor of botany in the Manila Normal School, Philippines. — Dr. Otto Drasch, professor of histology and embryology in the university at Graz. — Théophile Durand, director of the botanical gardens at Brussels. — M. H. Embrer, assistant in biology in the University of Toronto. — Dr. A. Ernst, docent for botany in the university at Zurich. — Dr. Ferdinand Filarsky, custodian of the botanical section of the Hungarian National Museum at Budapest. — Dr. Alexander Fleroff, docent for botany in the university at Moscow. — C. M. Fraser, assistant in zoölogy in the University of Toronto. — Dr. Ph. Glangeaud, adjunct professor of mineralogy in the university at Clermont, France. — Dr. Caswell Grave, director of the U.S. Fish Commission Station at Beaufort, N.C. — Prof. J. W. Gregory, acting head of the geological survey of Victoria. — Dr. Grinchant, adjunct professor of mineralogy in the university at Caen, France. — Dr. A. C. Haddon, advisory curator of the Horniman Museum at Forest Hill near London. — Dr. R. W. Hall, instructor in biology at Lehigh University. — Dr. Fr. C. C. Hansen, professor of anatomy in the university at Copenhagen. — C. Willard Hayes, geologist in charge of geology on the U.S. Geological Survey. — Dr. E. Johann Gerhard Holm, professor and director of the paleontological section of the Royal Natural History Museum in

Stockholm. — Dr. R. E. Hooper, assistant in histology in the University of Toronto. — Dr. Jaroslav J. Jahn, professor of geology and mineralogy in the Brünn Technical School. — Dr. Max Kœrnicke, docent for botany in the university at Bonn. — Dr. Richard Kolkwitz, botanist in the royal water-testing establishment in Berlin. — Dr. H. B. Kümmel, state geologist of New Jersey. — E. A. Macallum, assistant in biology in the University of Toronto. — Dr. W. J. Macallum, assistant in histology in the University of Toronto. — Dr. S. Magocsy-Dietz, professor of vegetable morphology and physiology in the university at Budapest. — Dr. R. Martin, professor of anatomy in the university at Giessen. — Dr. Franz Wilhelm Negr, docent for botany in the university at Munich. — Dr. Paul Parnuntier, associate professor of botany in the university at Besançon. — Dr. Paulke, docent for geology in the university at Freiburg i. B. — Dr. W. H. Piersol, instructor in biology and histology in the University of Toronto. — Dr. F. Ptieninger, docent for geology and paleontology in the university at Tübingen. — Dr. Ernst, Freiherr Stromer von Reichenbach, docent for paleontology and geology in the university at Munich. — Dr. Adalar Richter, professor of botany in the university at Klausenberg. — W. M. Smallwood, associate professor of zoölogy in Syracuse University. — Dr. Srdinko, docent for histology and embryology in the Bohemian University at Prag. — Dr. Studniczka, docent for zoölogy and comparative anatomy in the Brünn Technical School. — R. B. Thompson, assistant in botany in the University of Toronto. — Dr. Wilhelm Trabut, professor extraordinary of mineralogy in the university at Vienna. — Dr. Karl von Tubeuf, head of the biological division of the Imperial Health Department of Germany. — Dr. M. E. Wadsworth, geologist for the Pennsylvania State Board of Agriculture. — Henry L. Ward, custodian of the Public Museum at Milwaukee. — Dr. Eugen Warming, director of the Geological Survey of Denmark. — Dr. S. H. Westman, assistant in histology in the University of Toronto.

RETIRED.

Dr. Chr. Aurivillius from the charge of the entomological collections in the Royal Swedish Museum. — Professor W. H. Brewer from the chair of agriculture at Yale after thirty-seven years of service. — Dr. E. Bugnion from the chair of anatomy in the university at Lausanne. — François Crépin from the directorship of the botanical gardens at Brussels. — Miss Susan M. Hallowell from the chair of botany at Wellesley College. — Professor R. Sadebeck from the directorship of the Botanical Museum at Hamburg. — Professor E. B. Tylor from the keepership of the University Museum, Oxford.

DEATHS

Mr. Alfred W. Bennett, the well-known English botanist, January 23, aged 69. — Giuseppe Camillo Giordano, professor of natural history in the Technical Institute at Naples, November 17. — Professor Alpheus Hyatt, at Cambridge, January 15, aged 63. — Professor Axel Key, anatomist and bacteriologist, at Stockholm, December 27. — Dr. Johannes Christoph Klinge, head botanist of the St. Petersburg Botanical Gardens, aged 51. — J. H. Krelage, botanist (Liliaceæ), in Belgium, December 1. — Professor Ivan Muschketoff, geologist of the St. Petersburg Mining Institute, January 25. — C. L. A. de Nicéville, state entomologist of India, at Calcutta, December 3, of malarial fever. — Charles Roberts, British surgeon and naturalist, January 8. — Dr. E. Selenka, professor of zoölogy in the university at Erlangen, January 20, aged 60. — Flaminio Bandi de Selvi, entomologist (Coleoptera), at Turin. — James P. Shipman, local geologist at Nottingham, England, November 21, aged 53. — Dr. Charles Stuart, an English naturalist. — T. T. T. Thorell, arachnologist, at Helsingborg, Sweden, December 23, aged 71. — P. C. Truman, entomologist, at Volga, So. Dakota, October 27.

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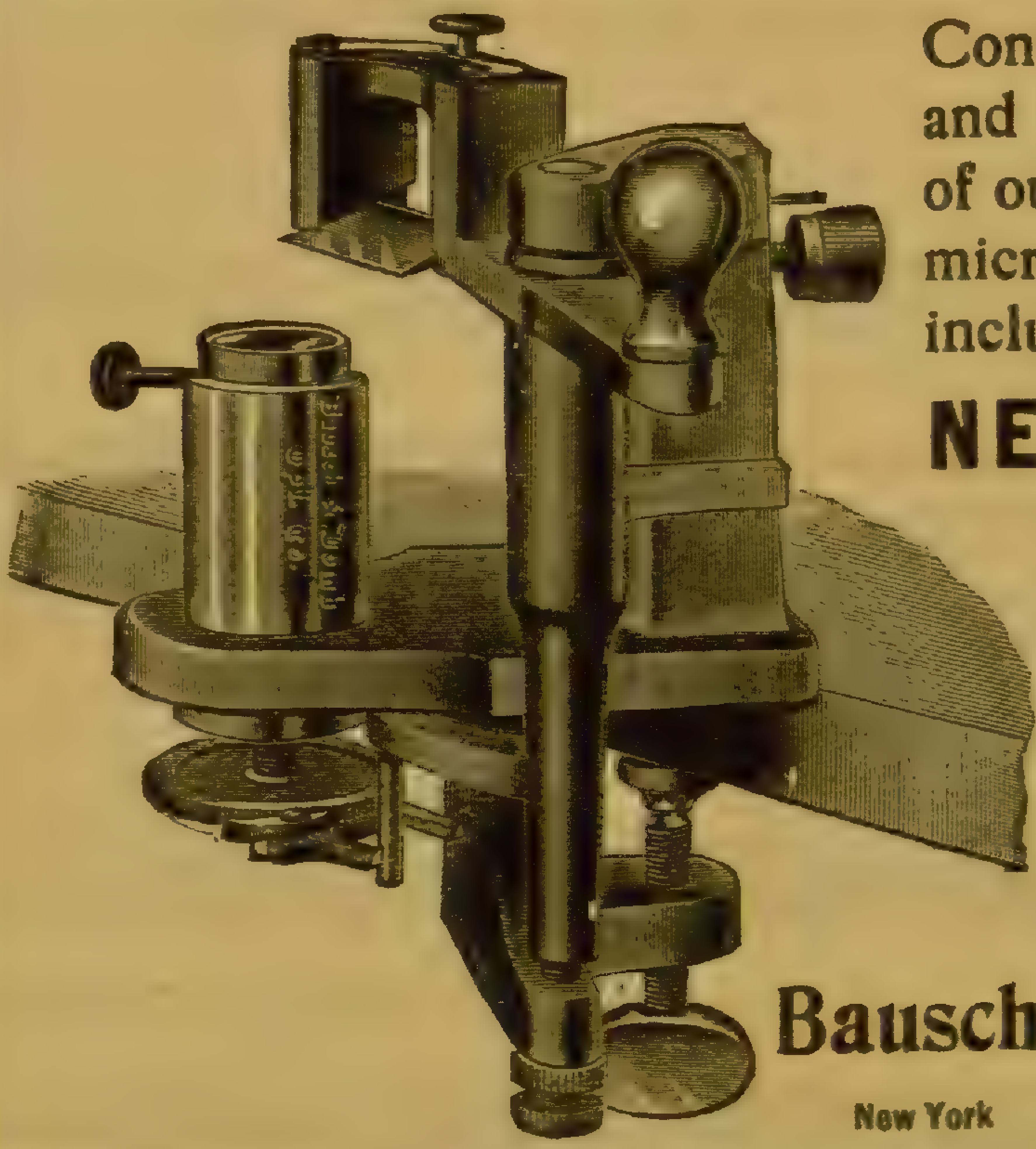

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DEVOTED TO THE NATURAL SCIENCES
IN THEIR WIDEST SENSE

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WILLIAM M. WHEELER, Ph.D., *University of Texas, Austin.*

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THE LIFE HISTORY OF ULULA HYALINA LATREILLE.[1]

J. F. McCLENDON.

WHILE collecting insects in Galveston, Texas, during June, 1900, I found specimens of *Ulula hyalina* Latreille, and at the suggestion of Dr. Wheeler kept them alive for the purpose of obtaining their eggs and following their larval and pupal development. The insects would fly against the sides of the large glass jar in which they were kept, and finally killed themselves; but two females deposited their eggs before they died. After many of the eggs and young larvæ were destroyed by various accidents, I finally succeeded in raising two larvæ. One of these I preserved when full-grown, the other after it had pupated. Later I obtained several imagoes from different localities and one full-grown larva from Austin, Texas. After reading the few notes that have been published on the life history of this interesting insect, I concluded that a more thorough treatment of the subject would not be out of place.

The first notes on the life history of the Ascalaphidæ, the family to which our insect belongs, were published in 1826

[1] *Contributions from the Zoölogical Laboratory of the University of Texas*, No. 27.

by Guilding, who is perhaps best known to zoölogists as the discoverer of Peripatus. These notes were on the life history of *Ulula macleayanus* Guilding,[1] which is synonymous with *Ulula hyalina*, or a variety of it, occurring in the island of St. Vincent, West Indies, where Guilding obtained his specimens. His description is meager and, to some extent, erroneous ; but the arrangement of the repagula has not been observed subsequently, to my knowledge. Hagen published a paper[2] in 1873,

FIG. 1.— *Ulula hyalina* Latr. Male.

which contained short descriptions of sixteen species of Ascalaphidæ. He repeated Guilding's descriptions and also described the larva of *Ulula senex* Burm., ignoring the fact that it was synonymous with *Ulula hyalina* and, consequently, also with *U. macleayanus*. Westwood wrote a review in 1888 of the previous papers on the life history of the Ascalaphidæ[3] and added a short life history of a Ceylonese species, perhaps *Ascalaphus insimulans* Walk., accompanied by figures, but

[1] The Genus Ascalaphus, *Transactions Linnæan Society*, vol. xv, p. 509.

[2] Die Larven von Ascalaphus, *Stettiner entomologische Zeitung*, Jahrg. xxxiv (1873), p. 33.

[3] Notes on the Life History of Various Species of the Neuropterous Genus Ascalaphus, *Transactions Entomological Society*, London, 1888, pp. 1–12, Pls. I, II.

failed, as did Guilding and Hagen, to work out the mouth parts thoroughly. A good description of the ant-lion's mouth parts, which are very similar to those of the ascalaphid larva, may be found in a paper by Redtenbacher[1] as early as 1884. Hagen and Westwood do not appear to have been familiar with this paper.

Ulula hyalina is distributed over the southern half of the United States, Mexico, and the West Indies, but is comparatively rare in many of the places where it is found. The insect (Fig. 1) when at rest remains motionless on some small branch or stalk, head down, with wings and antennæ closely applied to the branch, and abdomen erected and often bent so as to resemble a short brown twig or dried branch. On being approached, the insect moves to the opposite side of the branch, and, on being further disturbed, flies to another branch and alights with head up, then quickly turns and assumes its characteristic attitude. I found specimens on stalks of green sedge near the beach at Galveston, Texas. The insect contrasted strongly with the green stalk, but there were, near the tops of the stalks, brown seeds which resembled the insect and made it hard to find.

Fig. 2. — *Ulula hyalina*. Male, life size, resting on a stalk of green sedge.

Guilding says the eggs (Fig. 3) are placed in double series of 64 to 75, near the end of a branch, and are fenced off by little rods, which he called "repagula" (Fig. 3), placed on end and arranged in circles around the branch below the eggs, thus preventing the approach of insects and the wandering abroad of young larvæ until they can climb over the repagula and have likewise acquired strength enough to resist ants and other insect enemies. I observed one of my specimens from Galveston deposit its eggs and repagula; but it was too weak

[1] Uebersicht der Myrmeleoniden-Larven, *Denkschriften der Kaiserlichen Akademie der Wissenschaften*, Bd. xlviii, Taf. VII. Wien, 1884.

from confinement to remain on the stalk on which it rested and fell to the ground, so that I could not tell how it would have arranged the eggs under normal circumstances. These repagula I find to be in all probability abortive eggs, since dissection shows that some of the tubules of the ovary produce eggs, and others repagula.

The eggs hatch after nine to ten days. The young larva remains quiet a day or two, after which it seeks the ground. The larva, while growing in size, always retains the form shown in Fig. 4, except that after hatching and after each moult the head is proportionally larger. It hides in some slight depression or under the edge of a stone, with its body covered with sand and its mandibles widely extended so as to touch the fringe of hairs on each side of the head. Its brown color simulates the surroundings. Its body is hidden by the covering of sand, and the head is somewhat concealed by its peculiar covering of hairs (Figs. 4, 5, 12), so that small insects may crawl, unawares, too near the extended mandibles. In this case the larva thrusts out its head and snaps the mandibles together, pinioning the victim on the curved points. It then proceeds to suck out the juices of its prey like an ant-lion. In the latter this is accomplished, according to Redtenbacher, by the expansion of the pharynx, the juices passing through the duct formed by the mandible and maxilla fitting together (Fig. 6). The wound is kept open by the maxilla working like a piston in the groove of the mandible. The palpi at the same time move back and forth slightly. The labium and ligula are folded back into the mouth and adhere together so as to close the orifice in front. I have observed that the Ulula larva soon kills its victim, and at intervals opens its mandibles slightly, until one of them comes out, and then sticks it into a new place. This is continued until the skin is sucked dry,

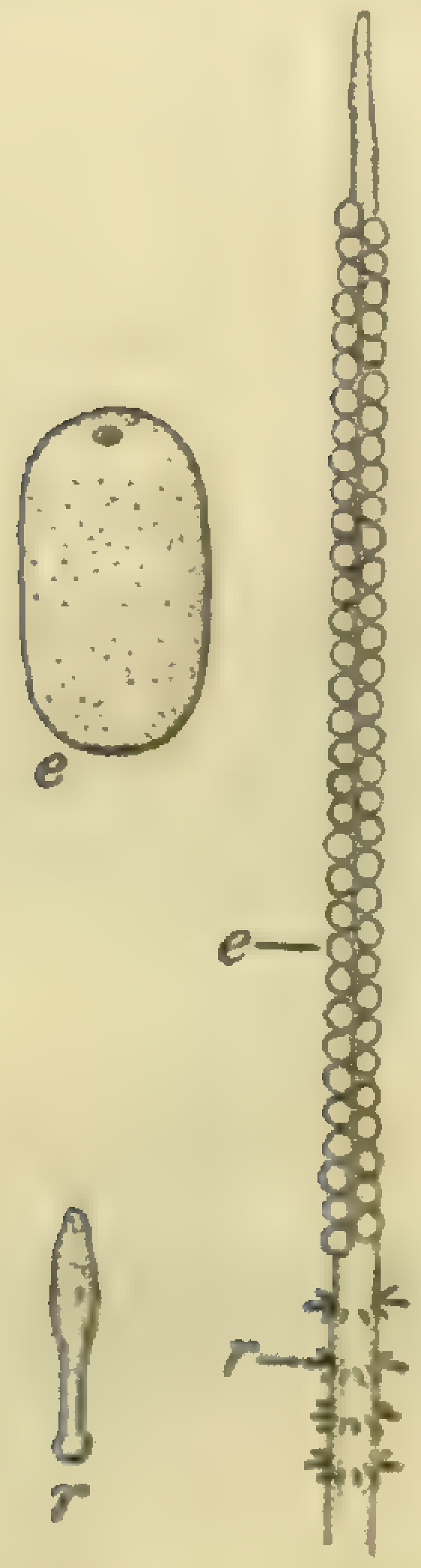


FIG. 3. — *Ulula hyalina.* Egg and repagulum; and a figure showing the arrangement of the eggs and repagula on a stalk, according to Guilding's description: *e*, egg; *r*, repagulum.

when the larva throws it aside and assumes its characteristic attitude and awaits another victim. On being disturbed the larva crawls away and seeks some other retreat. It often changes its hiding place at night, probably on account of scarcity of food. It always walks forward, contrary to the habit of ant-lions. The larval life lasts about sixty-two days, during which time the larva moults twice. It moults a third time inside of the cocoon, when it changes to the pupa.

As the habits of the Ulula larva are somewhat peculiar, it becomes of interest to compare them with the habits of the not very remotely related ant-lions (Myrmeleonidæ). According to Redtenbacher, the Myrmeleonidæ (Formicaleo, Acanthaclisis, and perhaps Palpares) lie quietly during the day like *Ulula hyalina*, except that the body, instead of being simply covered with sand, is buried slightly beneath the surface. They can walk backward as well as forward. At night they wander about in search of prey. Myrmecælurus can walk forward as well as backward, but digs a pit like the ordinary ant-lion. These latter, however, never walk forward. The digging of a pit by the ant-lion may be but a step removed from the habit of Palpares in burying its body. The ant-lion also has the instinct of wandering at night in search of a more favorable situation when food is scarce.

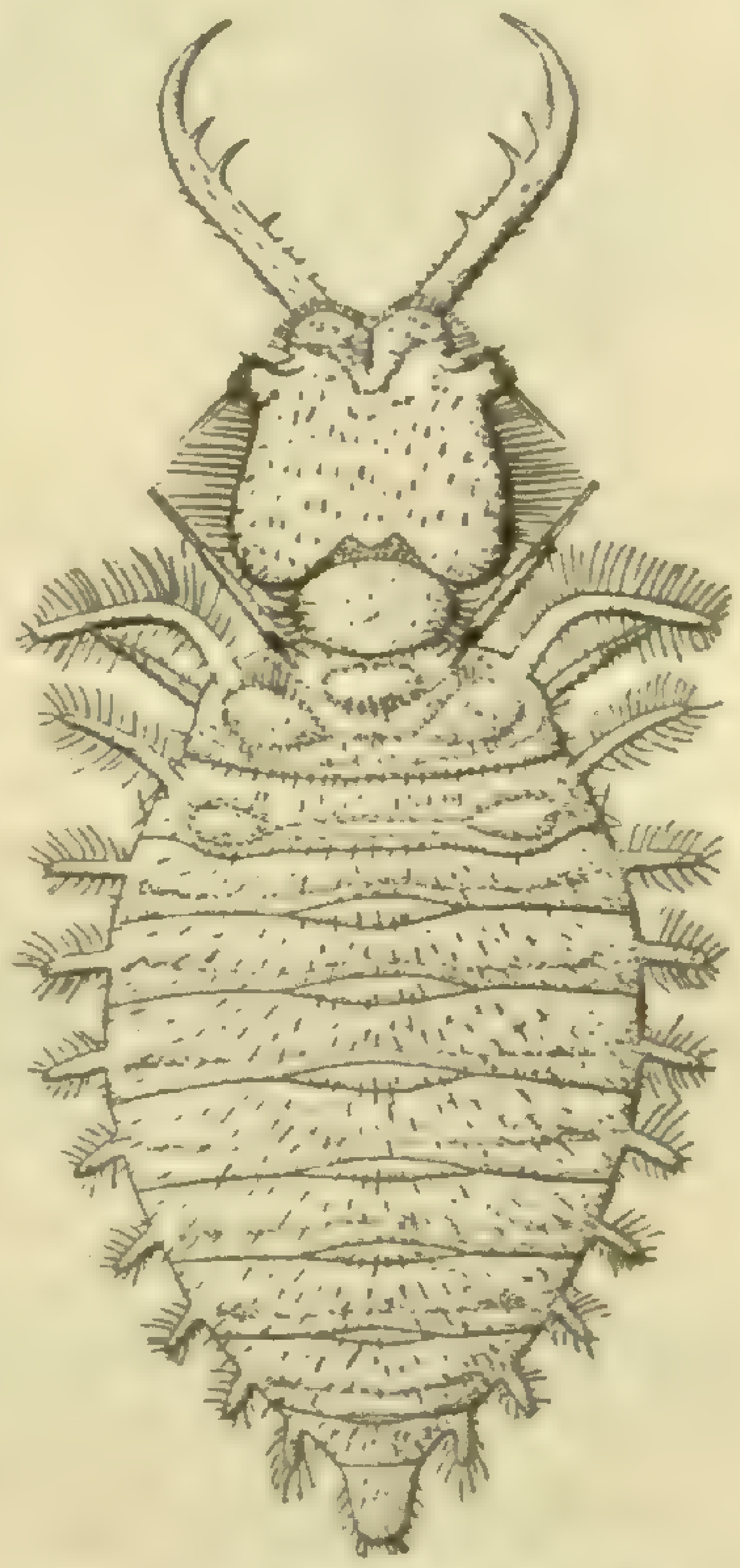
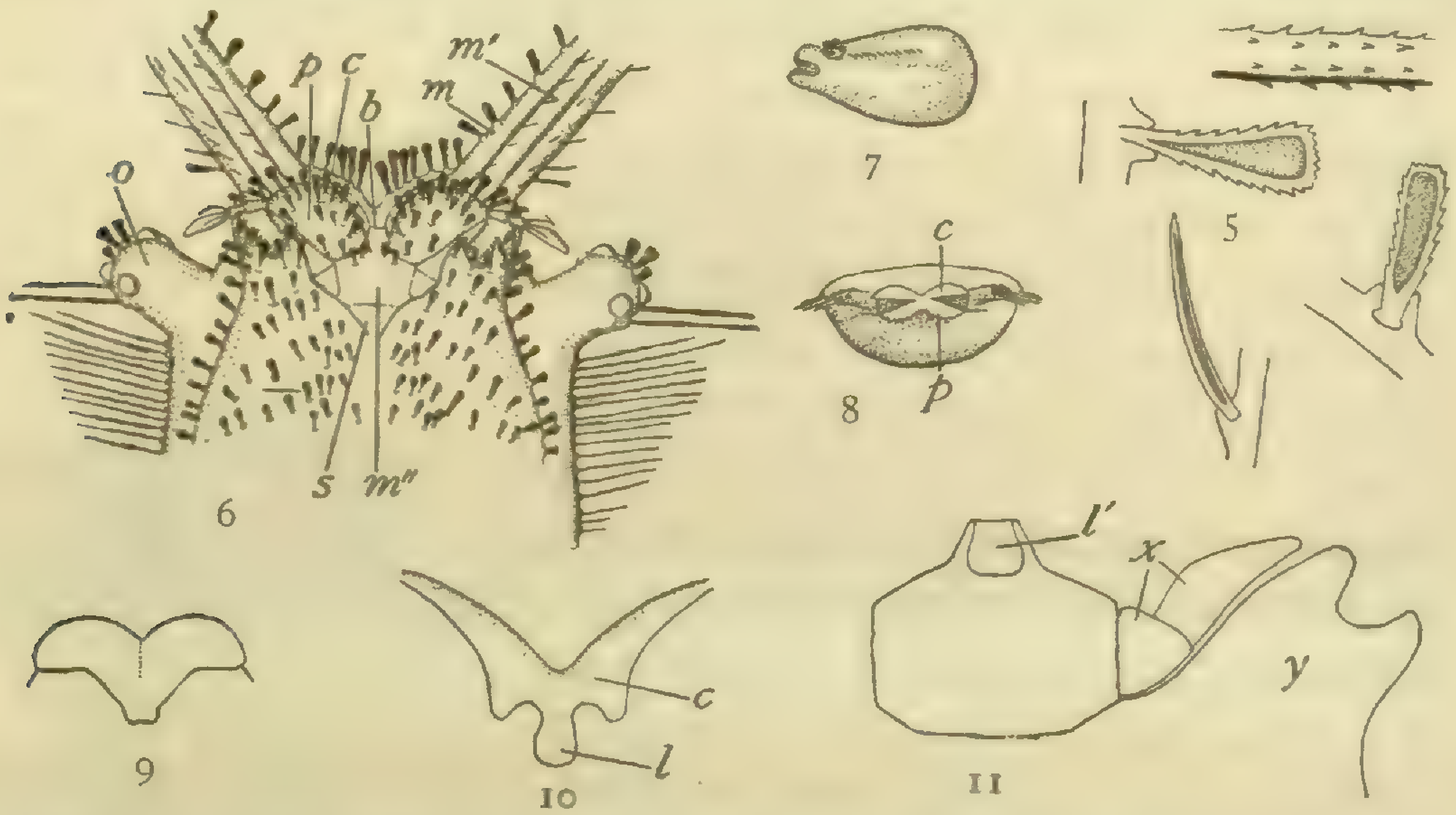


FIG. 4.— *Ulula hyalina.* Full-grown larva.

When the Ulula larva is full-grown it seeks some hidden place at night in which to pupate. Having found such a place, it spins a web, covering it with sand and such other small objects as may be at hand. It then gets inside the web and begins spinning a cocoon. The next day it remains quiet, and at night continues the work. I had an opportunity of observing several stages of the process, as my specimen spun its cocoon against the side of a glass jar partly filled with sand. The side next

to the glass could be seen through until after the third night, so that it must have required more than three days to construct the cocoon.

The mandibles (Fig. 15, *m*) of the pupa are toothed on their inner edges for the purpose of enabling it to bite a hole in the cocoon when the metamorphosis has been completed. I did not have an opportunity to observe the escape of the imago.



FIGS. 5–11. — *Ulula hyalina.* Larva. Fig. 5, three small setæ seen in optical section and a portion of a long one, surface view; Fig. 6, the head of a larval skin of the first moult, seen from below; Fig. 7, head with mandibles pulled out and setæ scraped off, seen from the side; Fig. 8, the same, from the front: Fig. 9, clypeus seen from above; Fig. 10, distal portion of the clypeus, seen from below; Fig. 11, inner surface of the mentum and adjacent integument. *c*, clypeus; *l*, labrum; *m*, mandible; *m'*, maxilla; *s*, submentum?; *m''*, mentum; *p*, labial palpus; *b*, point of contact of mentum and clypeus; *l'*, ligula; *x*, lobe of the mentum; *y*, lobe of the gena; *o*, ocular peduncle.

Below I have added descriptions of the egg, repagulum, larva, pupa, and cocoon.

Egg and Repagulum.

Egg (Fig. 3, *e*). — Length 1¾ mm. Ovoid, about twice as long as broad, cream-colored. An elevated ring, the micropyle, on upper pole.

Repagulum (Fig. 3, *r*). — Length 1½ mm. Slender, spindle-shaped. knobbed at base. Basal knob red; shaft brown.

The repagula are abortive eggs. Some tubules of the ovary bear eggs, others repagula.

According to Guilding the eggs are placed in a double alternating series of 64 to 75, near the extremity of the branch, and the repagula (barriers) are placed in circles around the branch, below the eggs (Fig. 3).

Larva (Fig. 4).

Length 13 mm. Head cordate, broad behind, tapering anteriorly, swollen beneath, thicker behind than in front, fuscous varied with black, covered with hair except on mid-ventral line, deeply emarginated on posterior border above, leaving an angular projection in center of emargination. Anterior border fringed with serrated hairs; lateral borders each with a very deep fringe. Ocular peduncles (Fig. 12, *o*) prominent, cylindroid, slightly flattened dorso-ventrally, each bearing seven simple eyes and thickly beset at the end with serrated hairs, two of which are very large and inclined backward. Eyes black, six on upper surface of ocular peduncle, five forming an incomplete circle around the sixth, one on under surface of ocular peduncle near the posterior outer margin. Antenna (Fig. 12, *a*) 1½ times as long as ocular peduncle, basal segment very large and broad at base, second segment much smaller, third still smaller and proportionately much shorter, and followed by a piece not definitely segmented and still more slender; the succeeding nine segments are of nearly equal size, the terminal segment is as long as the three preceding and ends in a tuft of small hairs: there is a lobe above the base of the antenna ending in a fringe of five hairs, — three stout serrated ones alternating with two slender smooth ones which terminate in stellate enlargements. Clypeus (Fig. 9) narrow behind, continued in front as a pair of semicircular lobes over bases of mandibles, middle of anterior border continued downward and reaching the mentum. Labrum (Fig. 10, *l*) small, infolded into the mouth. Mandible long, swollen at base, straight for three-fourths its length, then curving inward; curved portion free from hairs, inner edge set with three teeth, middle one largest, posterior one smallest, space between anterior and middle one smaller than that between middle and posterior one, mandible grooved on ventral side. Maxilla swollen at base, lying in groove of mandible, with which it forms a duct leading to the mouth, serrated on inner edge near tip. Mentum (Fig. 6, *m''*) nearly square, anterior border produced in the middle so as to

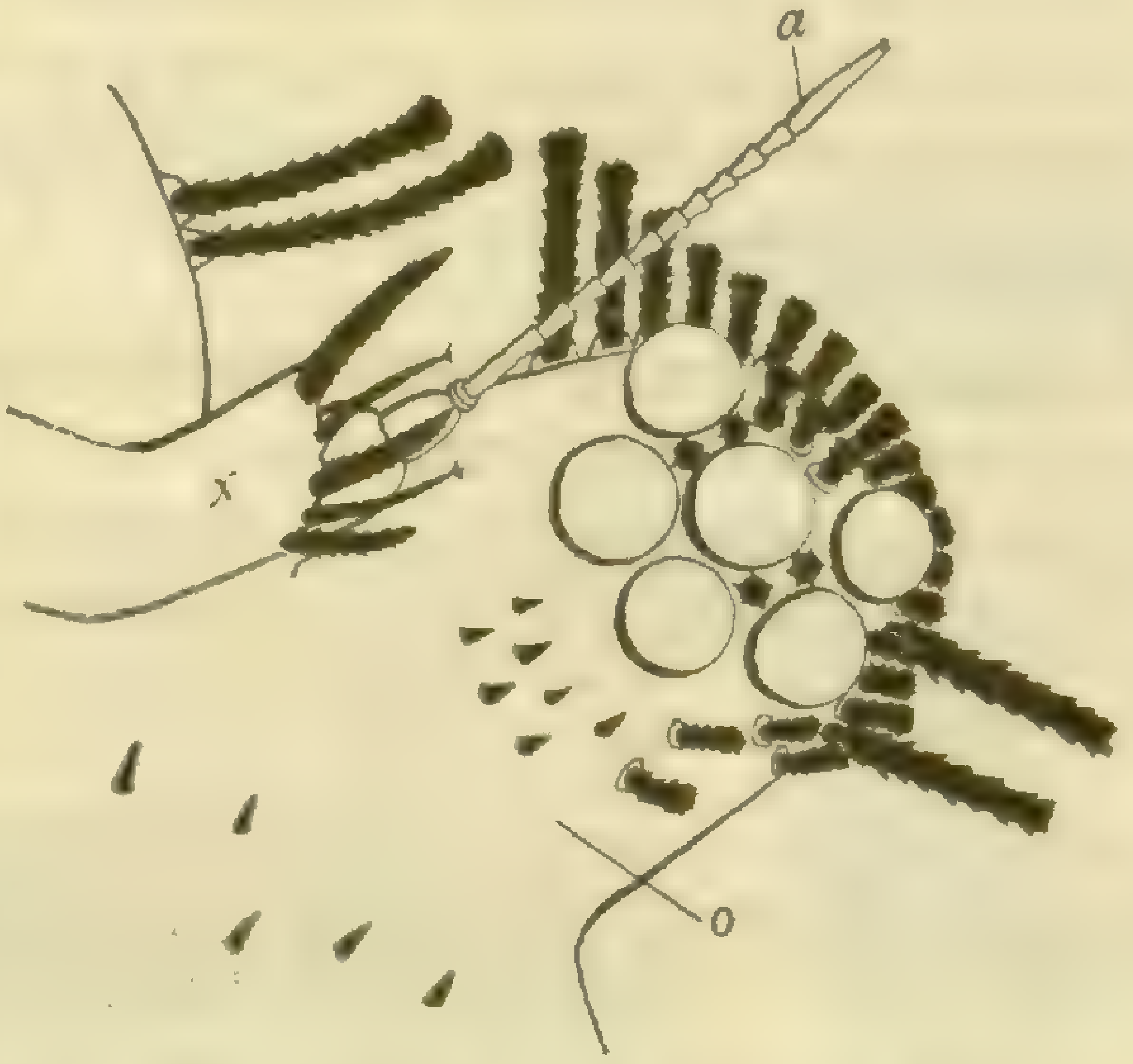


FIG. 12.—*Ulula hyalina*. Ocular peduncle of larva: *o*, ocular peduncle; *a*, antenna; *x*, lobe over antenna.

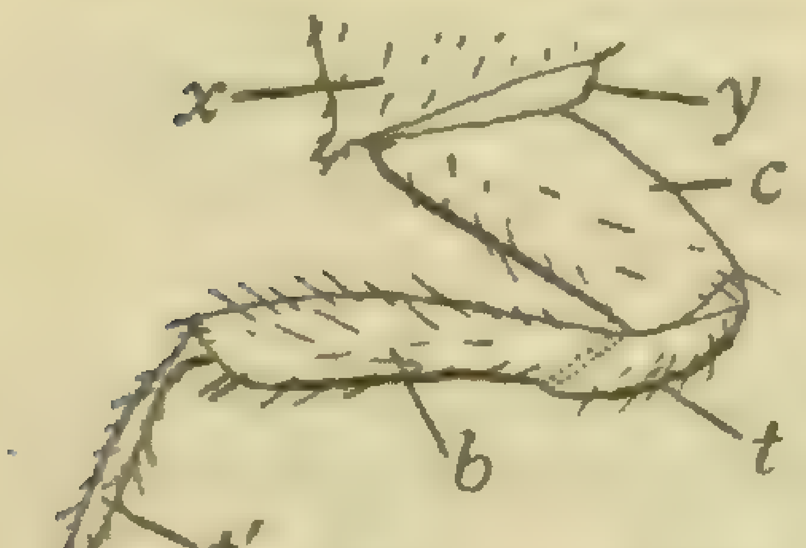


FIG. 13.—*Ulula hyalina*. Mesothoracic leg of larva: *x*, mesothorax; *y*, articular membrane; *c*, coxa; *t*, trochanter; *b*, femur; *t'*, tibia; *t''*, tarsus.

reach the clypeus, lateral margins produced into a pair of triangular lobes (Fig. 11, x) inclined forward and devoid of hairs, each divided by a suture into two triangles; ligula infolded into mouth, adhering to the labrum; basal segment of labial palpus very large, flattened, fourth segment as long as second and third combined. On each side of the mentum arises a lobe of the gena (Fig. 11, y) which projects over the base of the mandible, deeply emarginated on anterior border. The hairs (Fig. 5) on the head, as well as on the body, are of peculiar structure: the base of a hair is constricted so as to close the cavity within, and the integument is raised around the constricted portion; the hairs are of two kinds, smooth and serrated; some of the serrated hairs are enlarged at the tip.

Thorax flat, much broader behind than in front, luteo-fuscous mottled with fuscous, thickly beset with hairs, all of which are fuscous or black; prothorax freely articulated with mesothorax, much narrower than head, much broader than long; metathorax broader than head, bearing above three ellipsoid swellings, each of which has the margin depressed below the general level; one lies near the anterior border, the other two near the lateral borders and are connected by a deep groove; two pairs of lateral lobes, anterior pair short, conical, inclined forward, terminating in a few black setæ which are packed together so as to appear like the end of the lobe, second pair very long, inclined forward at base, then bent slightly backward, fringed with large, serrated hairs; there is a pair of spiracles below near the bases of posterior pair of lobes; metathorax broader than mesothorax, a pair of ellipsoid swellings above, similar to those on mesothorax, a pair of lateral lobes, shorter than pair on mesothorax, inclined forward, fringed with large hairs; a pair of spiracles below, near bases of lateral lobes; legs luteo-fuscous with fuscous hair, anterior pair small, each succeeding pair larger, coxa very long (see Fig. 13),[1] trochanter small and almost rigidly attached to the femur, tibia slender, tarsus of a single small joint, ungues black, much curved.

FIG. 14. — *Ulula hyalina.* Pupa.

Abdomen broad and thin, dorso-ventrally compressed, pointed behind, lateral margins very convex, luteo-fuscous mottled with fuscous, covered with hairs which vary from fuscous to black, flattened and wrinkled below,

[1] Redtenbacher (*loc. cit.*, Fig. 116) gives a different interpretation to the joints of the leg of the ant-lion. He calls coxa what I believe to be a much-developed articular membrane (Fig. 13, y), and what I have called the trochanter he regards as part of the femur. The articulation between the trochanter and femur is not well developed and allows very little movement, but it cannot be overlooked. I may add that my interpretation is based on comparison with the imago.

somewhat convex above, divided into nine segments; tergites, except last two, separated along middle, so as to disclose the articular membranes, — each tergite, except the last two, with a cross groove nearly reaching the lateral borders; each segment bears a pair of lateral lobes fringed with fuscous hairs; each segment also bears a pair of spiracles below, near the bases of the lateral lobes; last segment conical, truncated. There is a circle of black curved spines around anus.

Pupa (Fig. 14).

Length 12 mm., diameter in cocoon 6 mm., breadth of abdomen 4 mm. The pupa resembles the imago in general, but is much smaller and comparatively shorter.

Head short, and compressed against thorax; eyes fuscous, with a deep vertical fold at right angles to the sulcus; antennæ comparatively short,

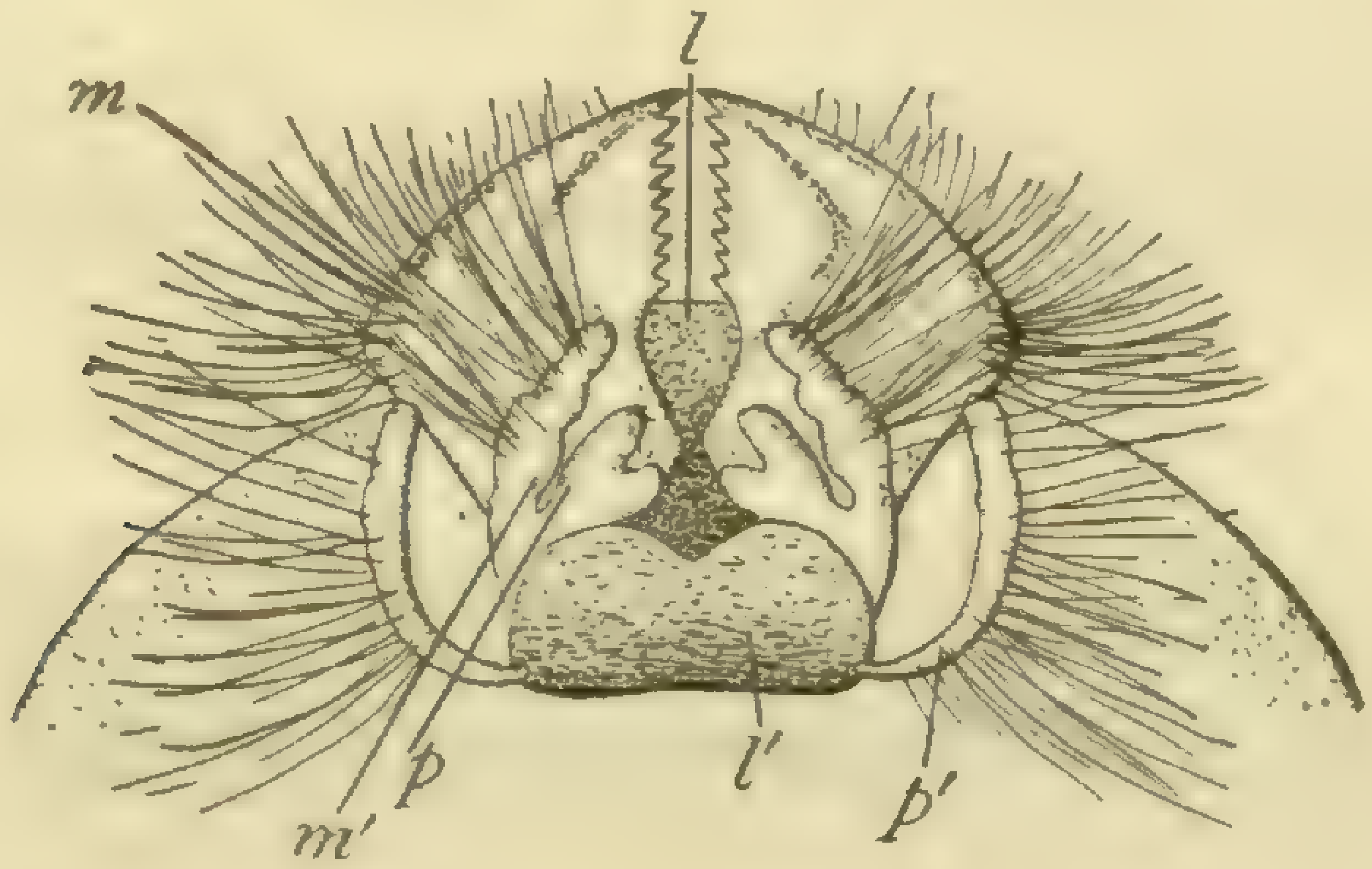


FIG. 15. — *Ulula hyalina.* Mouth of pupa from below: *l*, labrum; *m*, mandible; *p*, maxilla; *m′*, maxillary palpus; *l′*, labium; *p′*, labial palpus.

curved backward over the head, not knobbed, white; face light yellow, clypeus not distinct from labrum; mandibles (Fig. 15) stout, armed each with nine to ten teeth; inner edge of mandible rufo-fuscous, teeth black; gular region white; maxilla bilobate, maxillary palpus of three segments; labium slightly bilobate; labial palpus slender, smaller at base than at tip; mouth parts and vertex clothed with fine white hair.

Thorax short, cream-colored varied with ferruginous: prothorax compressed against back of head; wing sacs small, white; legs slender, white.

Abdomen short, curved under so that the anus reaches the mouth, cream-colored, varied with ferruginous, covered with fine white hair, a narrow mid-dorsal groove; each segment except the last two with a pair of spiracles.

Cocoon spherical, diameter 7 mm., made of silk.

UNIVERSITY OF TEXAS, AUSTIN,
November 20, 1901.

THE NEMERTEAN PARASITES OF CRABS.

WESLEY R. COE.

YALE UNIVERSITY.

In 1844 Kölliker found a small species of nemertean among the egg masses carried about on the abdominal hairs of a "small crab" at Messina. This worm he named *Nemertes carcinophilos* [1] and gave a fairly good description of its anatomy (**'45**). Fifteen years later van Beneden found a similar species among the eggs of the green crab (*Carcinus mænas*) on the coast of Belgium and, having overlooked Kölliker's descriptions, redescribed and figured it as *Polia involuta* (**'61**). The worms were said to be small, slender, yellowish or rosy in color, with two ocelli and a very short proboscis, armed with central stylet only. They lived in delicate mucous sheaths among the crab's ova, and often two individuals — a male and a female — lay side by side, or with their bodies somewhat folded, in the same tube. Van Beneden decided that the worm was not a true parasite, but rather that it merely occupied the egg masses of the crab as convenient places for building its tube and depositing its ova, as well as a place well protected and furnished with food. The females were 2–3 cm. in length, although the males measured scarcely 1 cm. Some of the younger individuals were only 2 mm. long. There are figures showing the form and color of the living worms, several of anatomical details, of the eggs in various stages of development, and of the early embryos before and after the molting of the larval skin. These figures are generally accurate, as is also the interesting account of the development. The large nerves passing forward from the dorsal ganglia are described as excretory canals opening on the lateral margins of the head, although the author states that they *seem* to be a continuation of the ganglia. The

[1] Spelled *cartinophilos*.

ciliated canals leading from the cerebral sense organs were in other species of nemerteans looked upon as excretory canals. The figures of the proboscis with its single central stylet and large glandular masses on each side are quite characteristic.

McIntosh ('73) gives a good description of the general anatomy of this species and an interesting account of its behavior in confinement, as well as the method of deposition of its ova. He also briefly describes the segmentation of the egg and gives several figures of the developing embryos. There is a good colored drawing of the living worm and figures illustrating the anatomy of the anterior portion of the body and of the proboscis, all of which are described in detail.

In 1874 Dieck ('74) found at Messina (where Kölliker's specimens of *N. carcinophilos* were obtained) a number of nemerteans among the egg masses of *Galathea strigosa*. But Dieck's description does not apply to any of the metanemerteans, and the species was named *Cephalothrix galatheæ*. The species agrees fully with Kölliker's *N. carcinophilos* in size, form, and color of body, in not having the head demarcated from body, in having two comma-shaped eyes in front of the ganglia, and in the absence of cerebral sense organs and cephalic furrows. In all these respects the description exactly corresponds with that of *N. carcinophilos*, but Dieck describes certain other anatomical peculiarities which separate the two forms widely, and certain others which have been found in no other nemertean. The proboscis is described as being without stylets, and the mouth is said to lie behind the brain. Dieck further describes remarkable appendages on the head which are believed to aid the worm in retaining its position on the crab. These "fingerförmige Greif oder Haftorgane . . . sind so contractil, dass sie nur bei starker Ausdehnung deutlich ins Auge fallen" ('74, p. 502); but he shows no indication of them in any of his figures. It seems possible that they may have been formed by a too severe pressure on the glass covering the worms, and thereby rupturing the integument. Dieck thinks he may have seen similar appendages on the posterior end of the single male which he found, but he could not be certain whether he saw them or not.

He also describes the ovarian pouches as opening ventrally, and states that their external openings are provided with contractile lids which serve to close the openings, except when the ova are being extruded. Both Dieck and van Beneden speak of the minute white specks seen on the bodies of the females with ripe ova, while Dieck's observations on the appearance of the egg strings, the eggs themselves and their early development, as well as the appearance and peculiarities of the embryos, answer equally well for Kölliker's species; and, finally, his statement that the worms, after having devoured the eggs of the crab, find their way to the gills, where they live as ectoparasites, is in perfect accord with the observations on *carcinophila* described below, although his interpretation of the life history of the worms seems to be in error.

While it would be unwarranted to say that Dieck's descriptions of the anatomy of his *Cephalothrix galatheæ* are incorrect in so far as they do not agree with the structures found in Kölliker's species, yet it would seem most remarkable if there were to be found in the same locality two species of nemerteans belonging to entirely different orders which agree so perfectly in color, size, external appearance; in possessing the same peculiarities in regard to the ocelli, structure of body walls, mucous glands, and other features; in having the same peculiar habits due to a parasitic life; in laying eggs which have the same appearance and mode of cleavage, and which in their development give rise to perfectly similar embryos. Likewise remarkable among the nemerteans, although it is known in a few forms, is Dieck's observation that while most of the eggs are laid before cleavage, yet fertilization and early cleavage sometimes take place within the body of the parent. McIntosh states that this is also true in *N. carcinophila*. It should be noted in this connection that Dieck found but a single male, which was 2 cm. in length, although the females were abundant and of much larger size, some of them being as much as 7 cm. in length. He considered it probable that the sperm from a single male entered the ovaries of all of the five or six females which might live on the same crab.

Whether the species described by Kölliker, van Beneden, and McIntosh will prove to be widely different, closely related, or identical with that studied by Dieck, future investigations must decide. Suffice it to add that Dieck was quite unacquainted with the descriptions of any of the other authors mentioned, and believed that he was describing a crab parasite for the first time. He shows by his descriptions that he knew very little of nemertean anatomy, and this fact might easily account for the strange anatomical peculiarities which he found the worms to possess. Careful comparison of his figures with those of van Beneden (**'61**) and McIntosh (**'73**) reveals such slight differences that we may well consider them as belonging to the same species; that they represent worms of different *orders* seems incredible.

Joubin (**'93**) has found Kölliker's species abundant on *Carcinus mœnas* at Roscoff, on the northern coast of France, and Giard (**'88**), on the coast bordering the Bay of Biscay, on the same species of crab. Giard (p. 496) found these worms on almost every crab examined which carried eggs, and has observed the same or a very similar species on *Xantho floridus*. This he calls *Polia xanthophila*, but gives no distinguishing peculiarities except that it is smaller in size.

On the *Challenger* Expedition Willemoes-Suhm (**'74**) found a small species of nemertean on the body of a species of crab (*Nautilograpsus minutus*) which lives on the gulf weed in the "Sargasso Sea," between Bermuda and the Azores. These little worms were only about 1–2 mm. long, but none of them were sexually mature. The suggestion was made that the nemertean inhabits the crab only when young, and that it lives freely on the gulf weed when mature. This form agrees with the other species of Carcinonemertes in possessing two large ocelli, although there is said to be a pair of accessory ocelli of extremely minute size near the proboscis. These are represented in the figure (**'74**). It is intimated also that the mouth lies behind the brain. The color of the worms was brownish. The stylet lies just back of the brain, and the proboscis is very short. The figure shows indications of two pouches of accessory stylets, although these are not mentioned in the

descriptions. Some of the worms are said to be found on various parts of the crab's body, being most abundant on the abdomen, but the gills are not mentioned. An account of this species is given also in the *Narrative of the Cruise of the Challenger*" (Vol. I, p. 169) and is reproduced in Hubrecht's report on the nemerteans (**'87**).

A further instance of a nemertean parasitic on Crustacea is mentioned by Quoy and Gaimard (**'33**), who describe from Amboina a small species, apparently belonging to the genus Tetrastemma, under the name of *Borlasia quadripunctata*. They state that although it usually lives in the sea, yet it is also found at times living in the barnacle (Anatifa).

So far as I know, the first observations of a nemertean parasite of the crab in this country are those by Prof. J. P. McMurrich, who writes me that he found the worms quite numerous among the egg masses attached to the abdominal hairs of a "lady crab" (*Platyonichus ocellatus*), July 6, 1889. These worms laid several strings of eggs in the manner characteristic of the species. The eggs developed normally, as described by van Beneden (**'61**), McIntosh (**'73**), and Dieck (**'74**).

I first found this nemertean on the gills of the lady crab at North Dennis, Mass., situated on Massachusetts Bay, Aug. 6, 1898, and have since found it abundantly in other regions south of Cape Cod.

The gills of a single crab often harbor as many as forty to sixty of these worms, which are of small size and sexually immature when found in this position, becoming full-grown and sexually mature only when living among the crab's ova. As found on the gills the worms vary in color from pale ocher to salmon, depending largely on the coloration of the intestinal canal. They are of all sizes up to about 15 mm. in length when extended and very slender — almost threadlike. The body is of about the same diameter throughout and is often folded once or twice on itself as it lies between the gill plates of the crab, imbedded in considerable mucus. The crab's gills are sometimes undoubtedly injured by the abundance of the worms, so that I am almost sure that the latter feed upon the blood in the gills. This was also Dieck's conclusion in regard to his

Cephalothrix galatheæ, where he believed that he found the crab's blood corpuscles within the intestinal canal of the worms.

In many of the crabs on which I found only a small number of the parasites no injury to the gills was apparent, the ability on the part of the crab to repair its injured tissues being sufficient to prevent the gills being destroyed. When the worms were abundant, however, some of the gill plates were blackened, torn, and degenerated.

A large number of lady crabs obtained from Woods Hole and Martha's Vineyard, Mass., in July and August, 1900, were examined, and the parasitic nemerteans found in the gills in about one-tenth of the number. When present on one side of the body they were almost always found on the other side also. I found them only on female crabs, and did not find them in the gills when the crabs were carrying eggs. The worms cling tenaciously to the gills when these are removed from the crab. A gill cut from a crab and placed in a dish of sea water is not deserted by its parasites for several days, — or not until it decomposes. When forcibly removed from the gills the worms live several weeks in sea water, crawling sluggishly about, and often collecting in masses with their bodies placed lengthwise or folded sharply so that the anterior portion of the body lies parallel and in contact with the posterior portion, exactly as when living in the gills. Masses of them often collect on the surface of the water where it comes in contact with the sides of the vessel.

They secrete a very sticky mucous covering and when touched with a needle or drawn into a pipette attach themselves to it with exasperating tenacity. After living several weeks without food the worms become much smaller than when first collected.

Several dozen spider crabs (*Libinia canaliculata*), some of which carried eggs, a number of blue crabs (*Callinectes hastatus*) with eggs, and many rock crabs (*Cancer amœnus*) and green crabs (*Carcinus mœnas*) without eggs were examined without finding any nemerteans. I quite expected to find them on the green crab because this is the same species as that on which they are so abundant in Europe. When a green crab is placed in a vessel containing the worms, these will crawl over the crab's

body, and a portion of them will be found among the gill plates after twelve to thirty-six hours, but many more remain clinging to the crab's legs. Their behavior to lady crabs, however, — males as well as females, — is quite different, and they quickly find their way to the gills. The few rock, spider, and blue crabs with which I experimented in this way did not prove attractive to the worms, although occasionally one of them would enter the gills. Far more of them remained attached to the basal joints of the legs for several days.

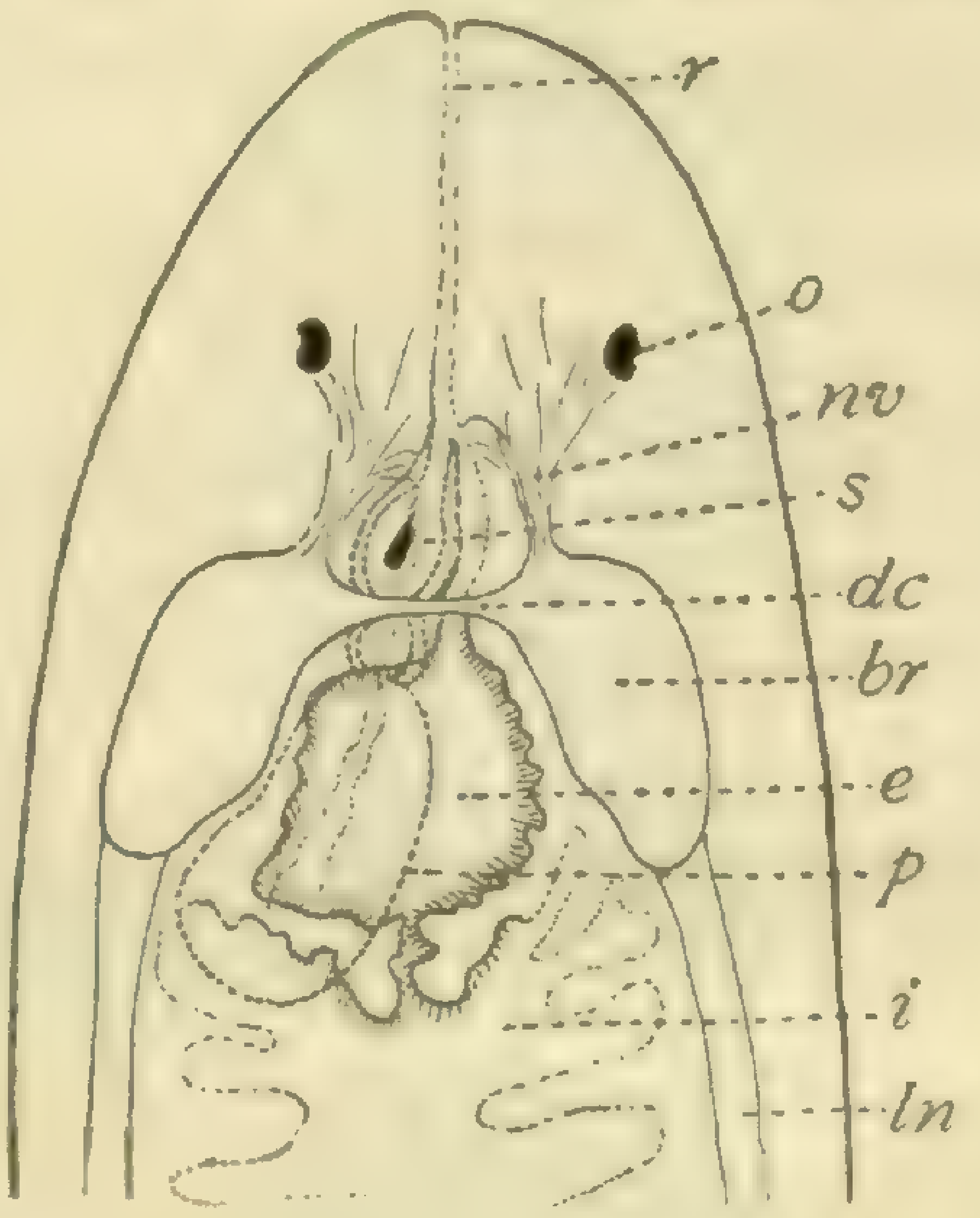


FIG. 1.— *Carcinonemertes epialti*. Anterior portion of body of living worm seen from dorsal surface. Slightly diagrammatic. *r*, rhynchodæum; *o*, ocellus; *nv*, nerve from dorsal ganglion supplying ocelli and other organs of head; *s*, central stylet; *br*, brain; *dc*, dorsal commissure of brain; *e*, œsophagus; *p*, posterior chamber of proboscis; *i*, intestine; *ln*, lateral nerve. × 80.

Sexually mature worms may be found early in July (and probably also in June) on the lady crabs carrying eggs. But the crabs with eggs are shy or else frequent deeper water, so that I did not find them nearly so abundant in the localities noted as were the males and smaller females without eggs.

All my observations on the species seem to indicate that the worms spend their whole existence on the crab, for I have found them in nearly all stages of development from the egg to the sexually mature worm. I have not, however, followed their history during the winter months, but suspect that this time is occupied as a period of slower growth.

The worms apparently occupy nearly a year in attaining sexual maturity, and their life history is briefly as follows: Eggs laid in mucous tubes among the egg masses of the crab in June and July; cleavage regular and nearly equal, with the formation of free-swimming ciliated blastula which develops into a ciliated embryo provided with ventrally placed mouth, a pair of ocelli, and an anterior and a posterior flagellum, or tuft of much longer, consolidated cilia. The embryo leaves the egg membrane in this condition and usually remains in the mucous tube or among the egg masses of the host, but may swim freely

in the water. The larval integument with its cilia and flagella is apparently shed, as described by van Beneden ('**61**) and Dieck ('**74**). At this time the embryos assume the form of the adult and crawl about instead of swimming. The integument of the young worms now becomes covered with cilia, as in the adult. After remaining for a time among the egg masses of

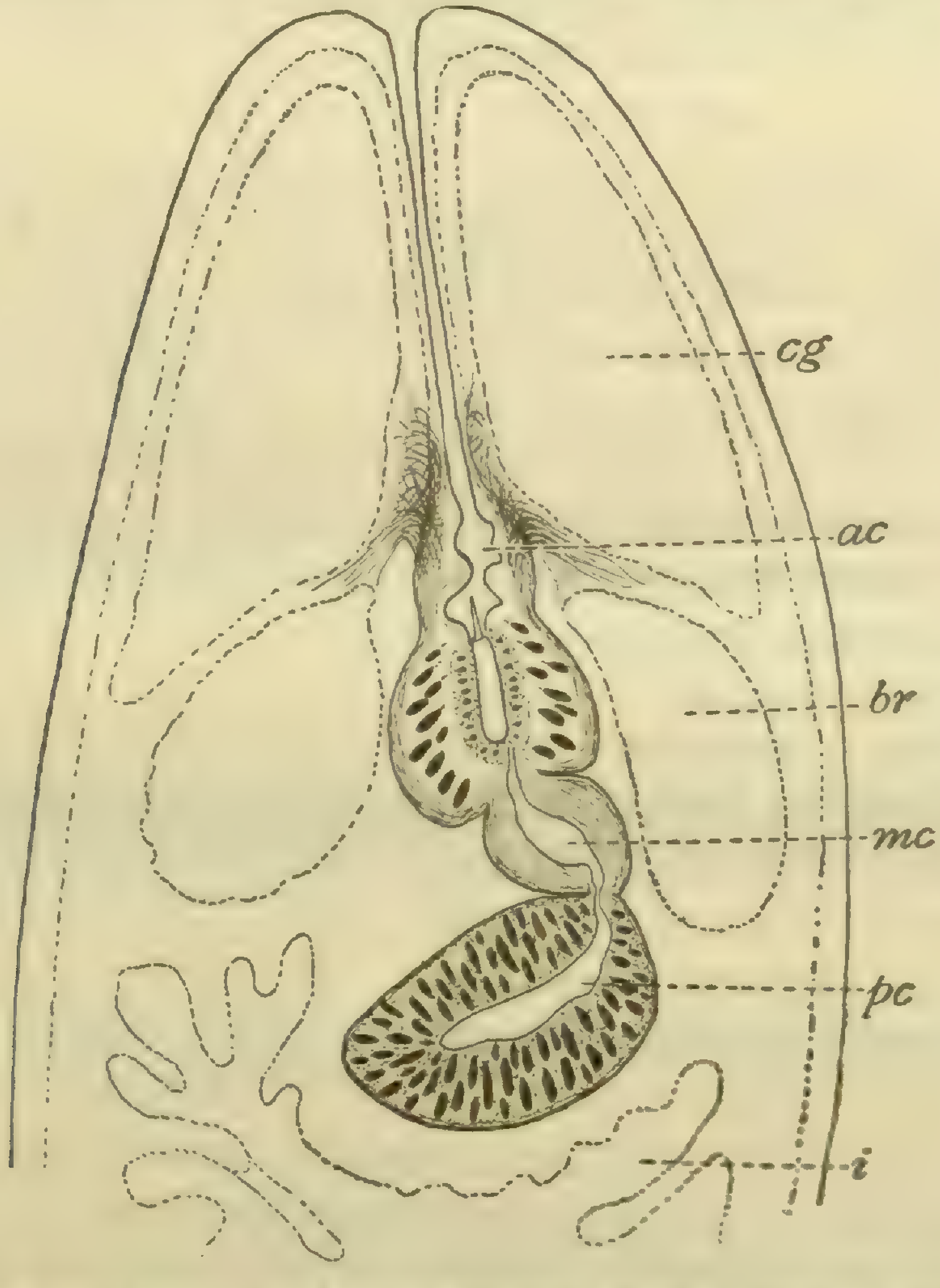


FIG. 2.— Horizontal section through anterior portion of body of *C. epialti*. Slightly diagrammatic, and the proboscis is represented a trifle too large. *cg*, outline of area occupied by cephalic gland; *ac*, *mc*, *pc*, anterior, middle, and posterior chambers of proboscis respectively; *br*, brain; *i*, intestine. × 150.

the host, or perhaps until her eggs have hatched, they wander about on her body, eventually reaching the gills. They are found in this position in July or August, and later, and here they probably remain until the crab produces another batch of eggs the following season. At this time they migrate again to the egg masses, where they become sexually mature. Those

embryos which swim away and which do not chance to find another suitable crab probably perish. The observations of the European writers mentioned above are mainly in accord with the account as here given.

The mature worms often become 25 mm. or more in length, are generally bright reddish orange in color, but some are reddish ocher and others brick red.

Their anatomical details agree closely with such descriptions of the European species as have been given, although these descriptions refer mainly to the external features. McIntosh's colored drawing (Pl. I, Fig. 5) of the worm, his figures of the anterior portion of the body and of the proboscis, as well as his detailed description of these parts, agree in most respects with the New England form, except that I find the posterior, glandular portion of the proboscis (Figs. 2–4, 6) much shorter than McIntosh represents. Yet it seems highly probable that such differences as appear to exist are largely accidental, and that the New England form is specifically identical with Kölliker's *Nemertes carcinophilos*. Joubin ('93) also gives a colored figure of the worm as it lies folded in its mucous sheath among the egg masses of the crab.

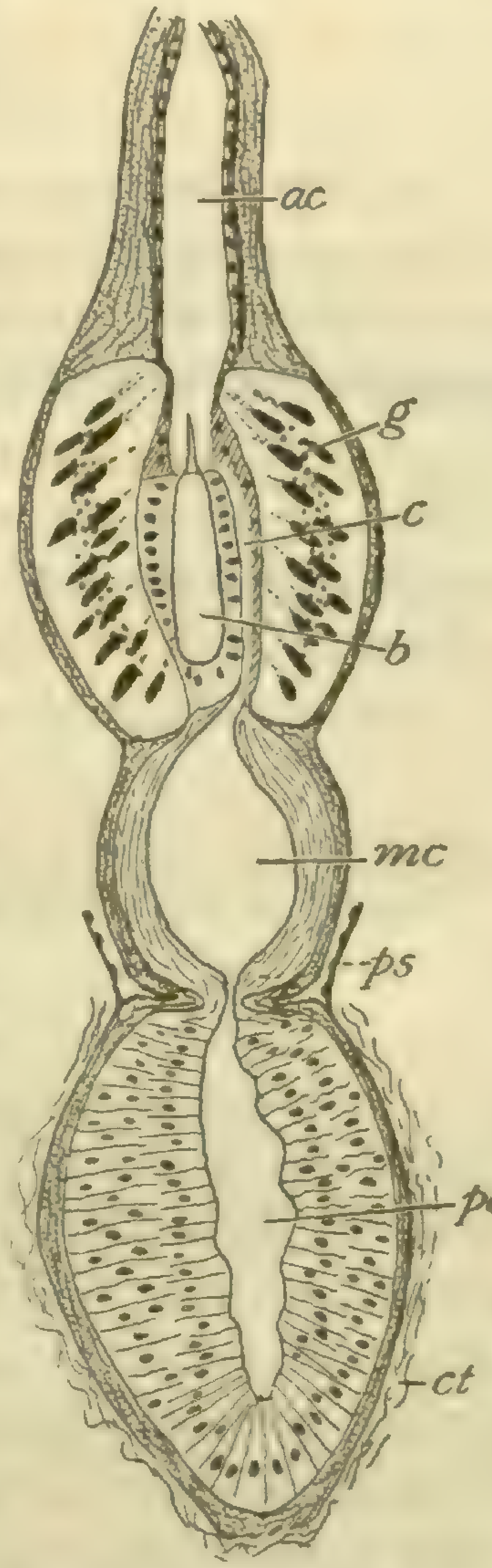


FIG. 3. — *Carcinonemertes epialti.* Optical section of proboscis removed from the worm. *ac*, *mc*, *pc*, anterior, posterior, and middle chambers respectively; *g*, gland cells; *c*, canal connecting anterior and middle chambers; *ps*, remnants of proboscis sheath attached to posterior chamber; *ct*, connective tissue in which posterior chamber is imbedded; *b*, basis of central stylet. × 300.

In internal organization the worms agree closely with a second species which I found abundantly on the gills of another species of crab (*Epialtus productus*) at Monterey, California, and which is described in detail below.

Both the Atlantic and the Pacific forms show such wide deviations from all other species of the genus Eunemertes, in

which Kölliker's form has been placed by Joubin, Bürger, and others, that the establishment of a new genus is imperative.

Carcinonemertes gen. nov.

Parasitic nemerteans living on various species of Crustacea. Body small, slender, often filiform, rounded, and of about the same diameter throughout; head without distinct lateral grooves, not demarcated from body. Body not usually coiled or much twisted, but often folded sharply so that the anterior portion of body lies parallel and in contact with the posterior portion. Mouth and proboscis open together; œsophagus extremely short, opening broadly into the intestine through a large muscular chamber situated immediately behind the brain (Fig. 6); intestine broad, with short lateral pouches which are but little developed in posterior portion of body.

Proboscis sheath without muscular walls, consisting merely of a thin membrane closely applied to the small proboscis. Proboscis but little developed, very small in size, and extremely short, without lateral pouches of reserve stylets, but armed with central stylet and basis only. Central stylet minute, usually one-third to one-half as long as basis, which is small and slender. Stylet region of proboscis can be withdrawn but little behind brain; consequently anterior chamber is very short, without distinct muscular layers, without distinct nerves, and without a thickened glandular epithelium such as occurs in almost all other nemerteans. Stylet apparatus imbedded in a strong muscular enlargement provided with numerous large glands (Figs. 2–4). Chamber immediately behind stylet, small but muscular, and with a lining of flattened epithelium, while the posterior proboscidial cavity is very short, often almost spherical, highly glandular, connected closely with the rudiments of the proboscis sheath and imbedded in the connective tissue which lies internal to the body musculature.

Cerebral sense organs probably wanting. Ocelli 2 (occasionally fragmented into 4).

Cephalic glands massively developed; a remarkable development of submuscular glands extends throughout the whole

length of the body, usually forming a distinct layer internal to the muscular walls of the body, and often thicker than all the other layers of the body wall combined.

Body musculature consists of a thin, oblique or circular muscular layer and a somewhat thicker, but yet weak, longitudinal layer internal to the former.

Brain and lateral nerves as in other metanemerteans.

Usually oviparous, though fertilization often takes place internally, and sometimes a portion of the ova of an individual

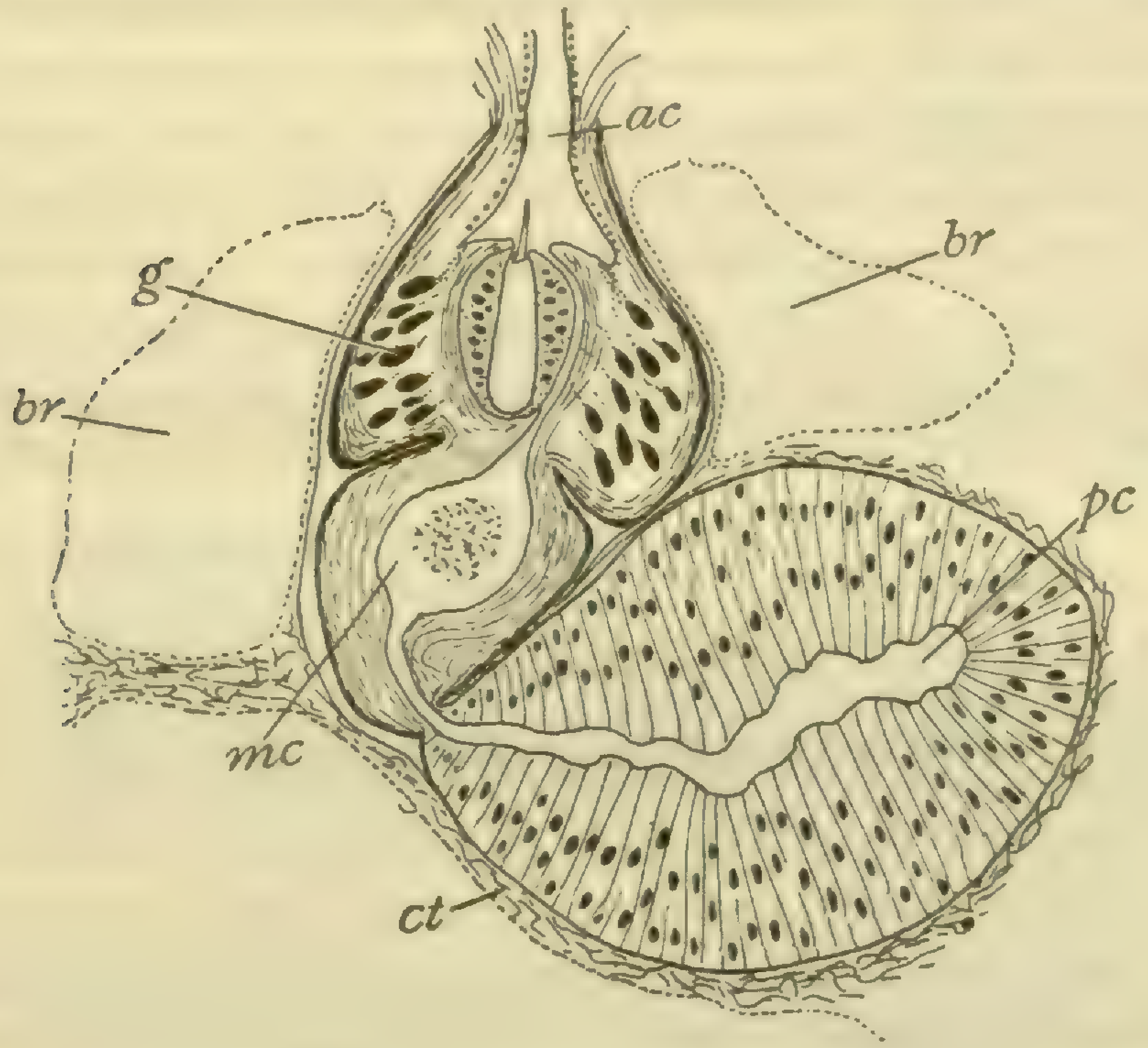


Fig. 4. — *Carcinonemertes epialti.* Horizontal section of proboscis in its natural position, showing the posterior chamber lying at right angles to the general axis of the proboscis. Reference letters as in Fig. 3. × 300.

may be retained in the body until the development of free-swimming embryos. Development without complicated metamorphosis, although the layer of ciliated cells originally covering the embryo is shed as development proceeds.

Carcinonemertes carcinophila (Kölliker).

Body slender, commonly 6–15 mm. long when found on gills, 20–70 mm. long when sexually mature; color yellowish orange,

pale reddish, rose pink (McIntosh), or bright brick red; posterior proboscis chamber very small, rounded; in ordinary states of contraction central stylet lies immediately behind brain. Basis of central stylet slender, about .025–.03 mm. in length by .006–.008 in average diameter. Central stylet about .008–.012 mm. long, or between one-third and one-half as long as basis. In general anatomical features the species closely resembles *C. epialti*, which is described in detail below.

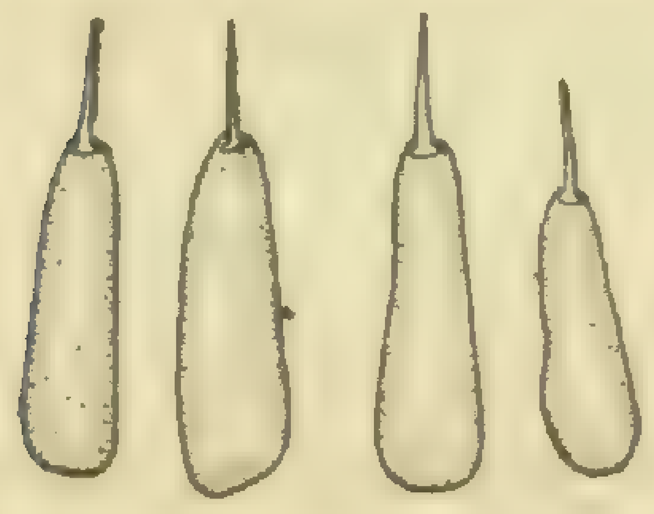


FIG. 5.—*C. epialti.* Several stylets, with their bases showing variations in form and size. × 400.

Parasitic on the gills of various species of crabs when young, migrating to the egg masses of the crab at the approach of sexual maturity, the young returning to the gills after a short period of development.

Distribution: Mediterranean Sea, Bay of Biscay, English Channel, on *Carcinus mœnas;* both north and south of Cape Cod, Mass., on *Platyonichus ocellatus;* France, Bay of Biscay (the same or a closely related species), on *Xantho floridus;* Mediterranean Sea (possibly the same species), on *Galathea strigosa.*

Carcinonemertes epialti sp. nov.

This is a much smaller and less slender species than the above when sexually mature, and differs from it in regard to the size of the posterior chamber of proboscis, in the stylet apparatus, and in many other anatomical details, although the differences, as will be described below, are not very considerable.

In general appearance, in color, arrangement of ocelli, œsophagus, intestine, and brain the two species are very similar. *C. epialti* also lives when sexually mature among the egg masses of a crab — in this case *Epialtus productus*, the common kelp crab of the California coast.

Upwards of one hundred of these little worms were found among the eggs of a single crab at Monterey, Cal., Sept. 3, 1901. In practically all, the sexual products were nearly mature, but no eggs were laid in confinement. The worms lived only a few days in a dish of sea water and appeared less hardy than the species on the Atlantic coast. I was unable to determine

whether the worms pass their early life on the gills of the crab, as does *C. carcinophila*, but suspect that this may be the case.

The species may be described in detail as follows: Body small, rounded, slender, of the same diameter throughout; sexually mature individuals about 4–6 mm. in length and less than half a millimeter in diameter; head not demarcated from body; lateral grooves and cerebral sense organs very inconspicuous or wanting.

Color, bright orange, sometimes inclining more to reddish and sometimes to yellowish. Head a little paler, for the color is largely due to the intestinal lobes which extend forward to the brain.

A pair of ocelli of irregular outline, but sometimes crescent shaped, lie about halfway between the tip of the snout and the brain (Fig. 1). Sometimes the ocelli are irregularly fragmented, and the pigment is arranged in four irregular masses.

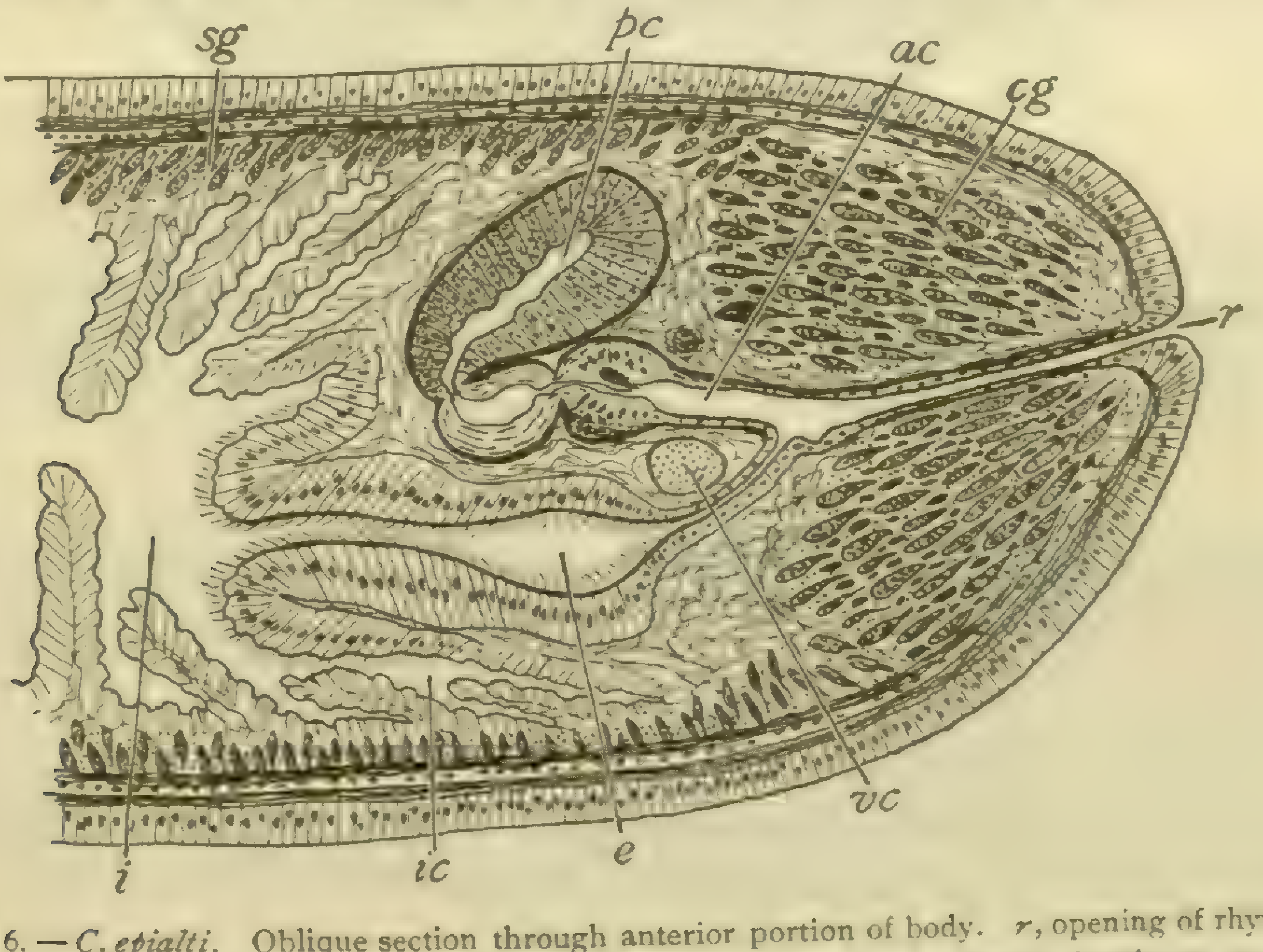


Fig. 6. — *C. epialti*. Oblique section through anterior portion of body. *r*, opening of rhynchodæum: *cg*, cephalic glands: *ac*, *pc*, anterior and posterior proboscis chambers: *sg*, submuscular glands; *vc*, ventral commissure of brain; *e*, œsophagus; *ic*, rudimentary intestinal cæcum; *i*, intestine. × 200.

Proboscis sheath greatly reduced, extending but little posteriorly to the brain, where it becomes united with the posterior chamber of the proboscis (Fig. 3). The sheath consists merely of few fibers of connective tissue supporting a very thin, flattened epithelium, and can be seen only in favorable preparations.

Proboscis very minute and short, extending scarcely more than its own diameter posteriorly to the brain (Figs. 1, 2, 6). Rhynchodæum (Fig. 6, *r*) slender; œsophagus separates from proboscis just in front of brain (Fig. 6). Anterior chamber of

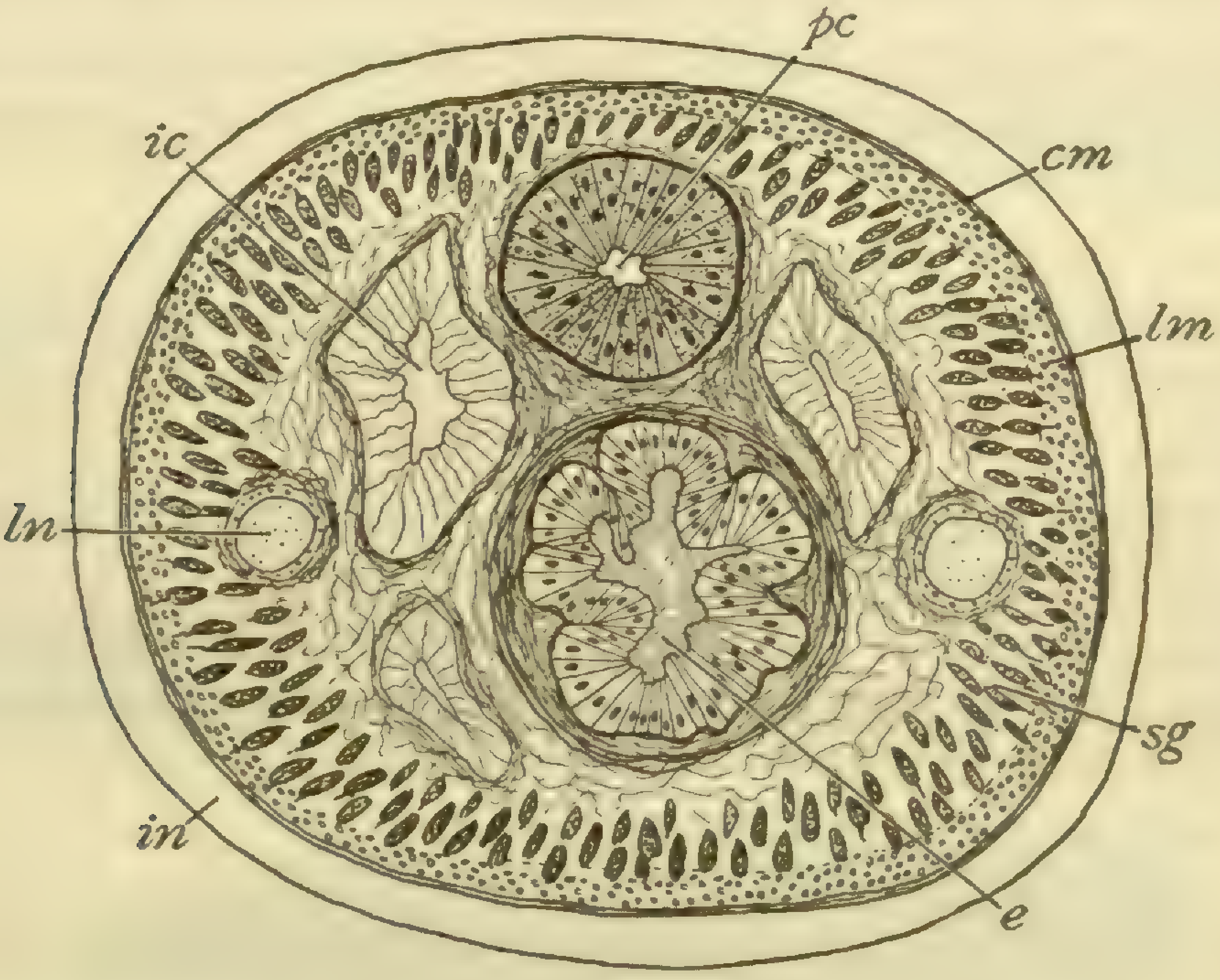


FIG. 7.—*C. epialti.* Transverse section of body immediately back of brain. The posterior chamber of the proboscis (*pc*) is firmly imbedded in the surrounding connective tissue. Three lobes of the very short intestinal cæcum (*ic*) are seen; *e*, œsophagus lined with cilia; *cm*, *lm*, circular and longitudinal layers of muscles; *sg*, submuscular glands; *ln*, lateral nerve; *in*, integument. × 200.

proboscis (Figs. 2, 3, *ac*) very small, not as long as the diameter of a brain lobe, lined with thin, scarcely glandular, epithelium. Stylet region swollen (Figs. 2–4) and provided with large and abundant gland cells (*g*) which open both into the anterior chamber and into the narrow canal connecting this with the cavity behind the stylet region.

Basis of central stylet slender, about three to five times as long as broad (Figs. 3–5), measuring about .027–.033 mm. in length and .005–.008 mm. in diameter. Basis slightly larger posteriorly than at attachment of stylet, often somewhat asymmetrical, as shown in Fig. 5. Stylet rather slender, a little less than half as long as basis, measuring .012–.015 mm. in length. Basis imbedded among the gland cells and surrounding muscles in a single layer of columnar cells with oval nuclei

(Figs. 3, 4) at right angles to its longitudinal diameter. There is no trace of accessory stylets.

The usual small, oval middle chamber lies directly behind the stylet region and connects with the anterior chamber by a canal (Figs. 3, 4) which passes close beside the basis of the central stylet and which, though narrow, is broader than in many other metanemerteans. The middle chamber, behind the stylet, is highly muscular, lined with flattened epithelium, and is often filled with fluid containing an abundance of granules resembling hardened secretions (Fig. 4). These, I think, originate in the posterior chamber as described below.

The proboscis now bends sharply on itself in ordinary states of contraction and ends in an oval chamber with small lumen and very massive glandular walls (Figs. 2–4, 6). The cells lining this chamber are highly columnar, irregularly arranged

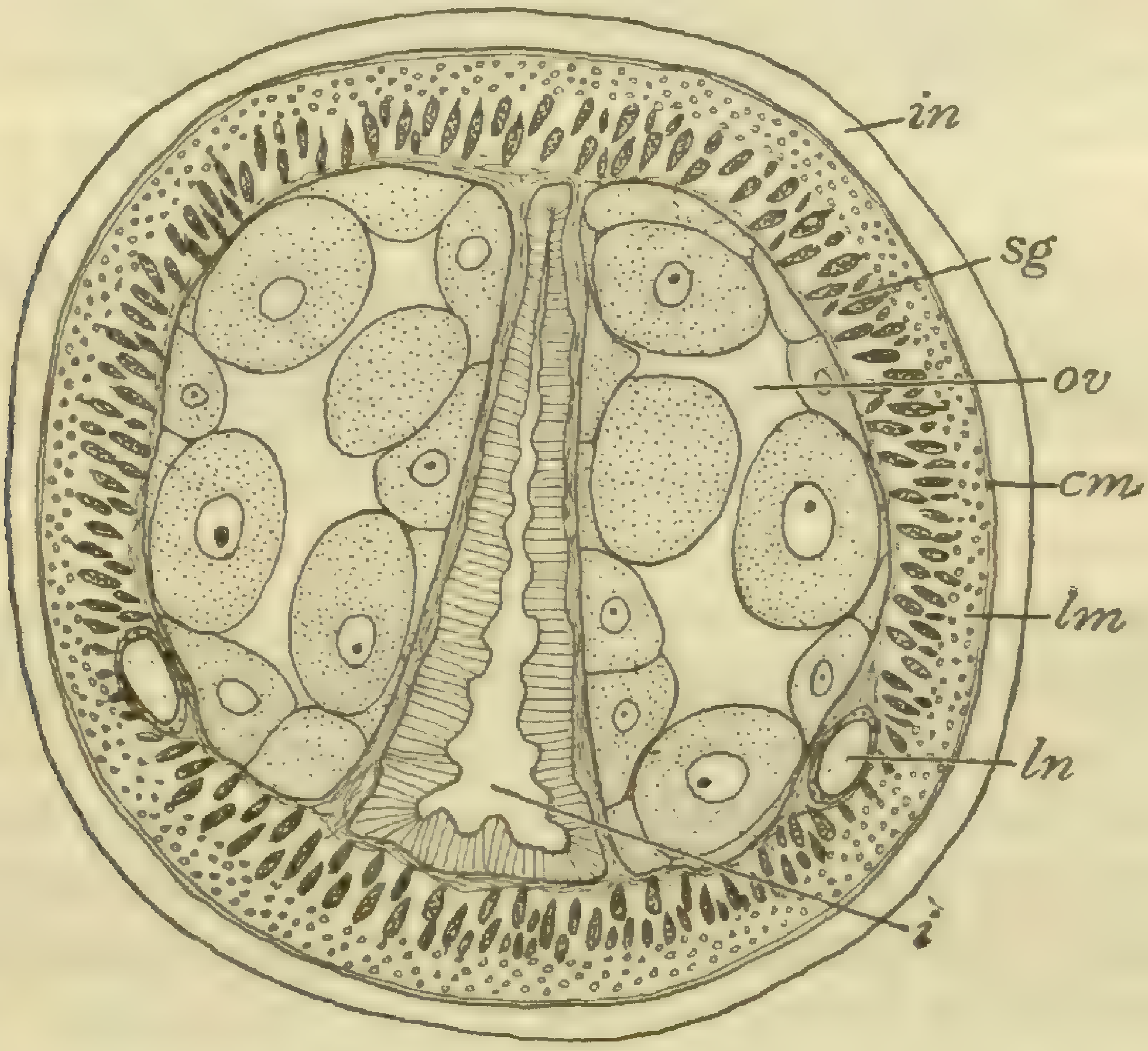


FIG. 8. — Transverse section of body of *C. epialti*, showing the thick layer of submuscular glands (*sg*) and the ovaries (*ov*) with large ova. The intestine (*i*) is reduced to a narrow canal. Other reference letters as in Fig. 7. × 200.

in several layers, and are thickly packed with secretions which have great affinity for ordinary stains. This posterior chamber is closely imbedded in the surrounding connective tissue (Figs. 4, 7), and this appears to be connected with the muscular

walls of the œsophagus. Its movements are doubtless to a great extent dependent on the contractions of the œsophagus, which, as described below, is converted into a sort of muscular pharynx.

The stylet can hardly be moved much beyond the external opening of the rhynchodæum, and from a study of its structure alone it is hard to conceive how it can be moved for even this short distance, imbedded as it is among the other tissues. By crushing and many kinds of stimuli I have seldom been able to cause the worms to move the stylet region to any extent either forward or backward. It nearly always remained in the vicinity of the brain, as shown in the figures. It is my opinion that the proboscis can be everted only far enough to bring the stylet a little beyond the opening of the rhynchodæum on the tip of the snout, as figured by van Beneden (**'61**), and that the œsophageal muscles aid in this movement. At the tip of the snout the stylet can puncture the tissues and blood vessels of the crab's gills. With the rhynchodæum of the worm widely opened and closely applied to the point of puncture, the blood and nutritive fluids exuding from the wound can be drawn directly into the rhynchodæum and thence into the œsophagus by the contraction of the muscular walls of the latter.

The œsophagus, which leaves the rhynchodæum just in front of the brain (Fig. 6), passes beneath the ventral commissure as a narrow tube lined with rather flat cells, as in other genera. Just back of the brain, however, it becomes enormously enlarged with high, columnar, ciliated epithelium, richly provided with gland cells. This portion of the œsophagus is highly muscular and somewhat barrel shaped (Fig. 6), projecting a little way backward into the broad intestine which immediately follows posteriorly. Its posterior portion is therefore surrounded by the intestine, as shown in Figs. 6, 7. Its opening into the intestine is wide and has thickened lips. The backward and forward motion of this barrel-shaped portion of the œsophagus in all probability aids in the eversion of the proboscis, as well as acts as a suction pump to draw in the nutritive fluids from the crab's gills.

The intestinal lobes surrounding the end of the œsophagus (Figs. 6, 7) indicate rudiments of the intestinal cæca found in

other genera. The intestinal canal is broad, with short lateral pouches which become very much reduced towards the posterior end of the body.

The nervous system shows few deviations from that in related genera. The brain is fairly well developed as shown in Fig. 1. From the dorsal lobes a pair of large nerves (Fig. 1, *nv*) pass anteriorly to the eyes and anterior portions of the head. These are easily seen in living worms. I found no indications of cerebral sense organs either when the specimens were stained

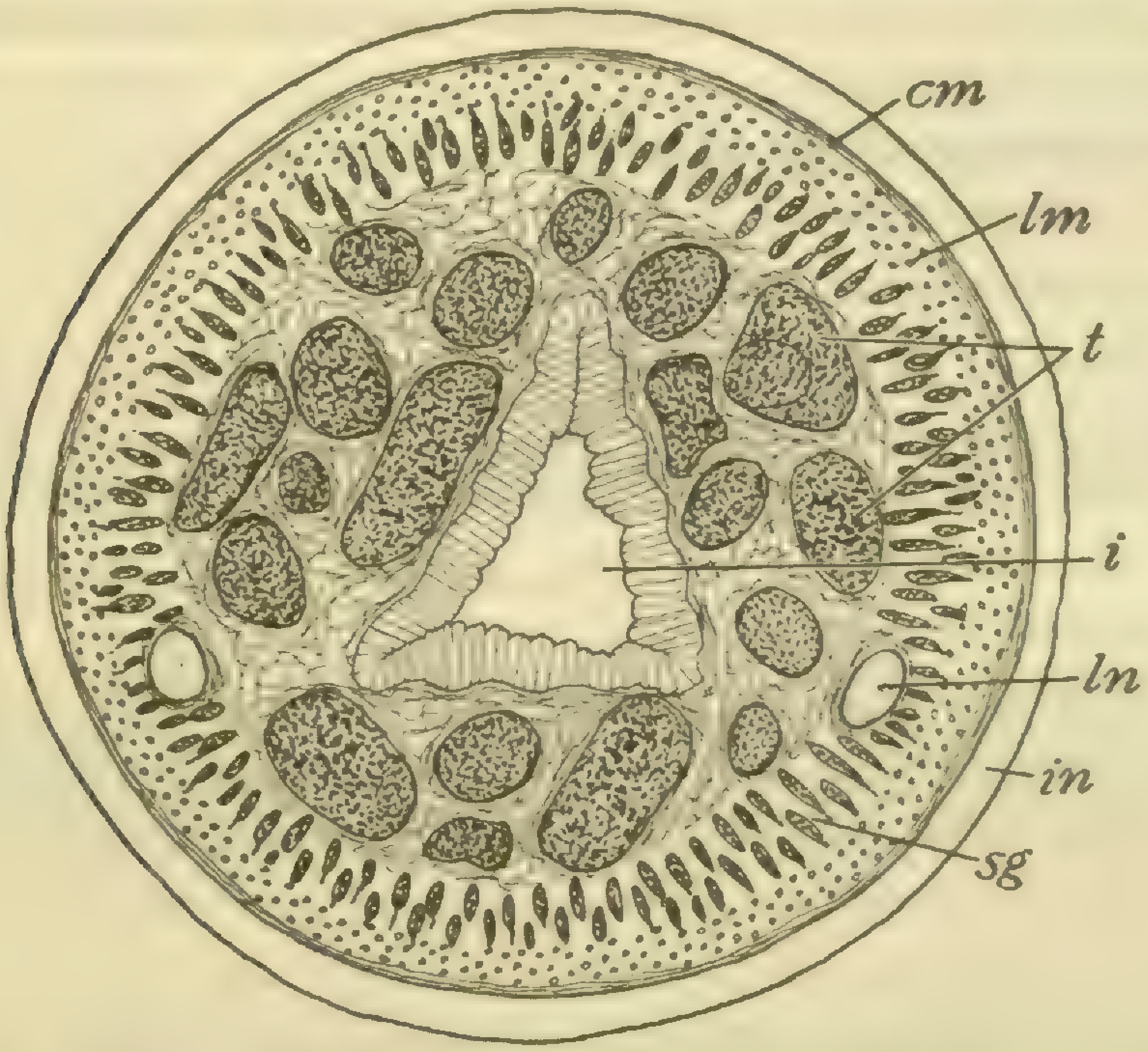


FIG. 9.—*C. epialti.* Transverse section of body showing the large number of spermaries (*t*) and their distribution throughout the body. Reference letters as in Fig. 7. × 200.

in toto or when examined in sections. I also failed in my attempts to locate the efferent nephridial ducts.

Throughout the head the tissues are crowded with the cephalic glands. Those situated more anteriorly open mainly on the tip of the snout (Fig. 6, *cg*), but farther back they open directly outwards on all sides of the body. Back of the brain they pass gradually into the submuscular glands which extend as a distinct layer throughout the length of the body. The glandular cells composing this layer open directly outward to the surface of the body (Figs. 6, 7, 8, *sg*) and are situated on the whole circumference of the body immediately internal to the

longitudinal muscular layer. The glandular layer is in most regions so massively developed that it exceeds in thickness all the other layers of the body wall combined. The secretions of these glands furnish the sticky mucus by means of which the worms cling so tenaciously to the crab or to other objects.

The outer epithelium is as in other genera, and is richly provided with glands.

The muscular layers of the body wall consist of a thin, external circular or oblique layer of muscles and an internal longitudinal layer (Figs. 7, 8), somewhat thicker than the former, but yet thinner than in most related genera. The lateral nerves occupy the usual places internal to the longitudinal muscular layer. In this species, however, they lie internal also to the thick layer of submuscular glands (Figs. 6, 8, 9, *ln*), and therefore nearer the center of the body than in other genera where these glands are not so highly developed.

There is very little body parenchyma, the intestine filling most of the space internal to the glandular layer, except at the time when the genital products are developing. The pouches of genital products become enormously developed and encroach greatly upon the intestinal canal at the time of sexual maturity (Figs. 8, 9). The genital pouches extend much farther forward than in almost any other nemertean, reaching very nearly to the brain. The ovaries (Fig. 8, *ov*) are regularly paired, with a single large pouch containing usually from 12 to 30 ova between each pair of intestinal lobes. The spermaries, on the other hand, are far more numerous, surrounding the intestinal canal on all sides. As many as fifteen or more separate spermaries (Fig. 9, *t*) are sometimes found in a single transverse section. As in most parasitic animals the abundance of sexual products is greatly in excess of that in related non-parasitic forms. This is also well illustrated in Bergendal's recent description (**'00**) of Gononemertes, a nemertean parasitic in the tunicate Phallusia. There is a resemblance also in other anatomical features, — in the excessive development of the cephalic glands, in the short posterior chamber of the proboscis, and in the slight development of the intestinal cæca. Of the two genera, Carcinonemertes appears to be far more degenerate than

Gononemertes, although it still retains ocelli and has a central stylet in the proboscis.

Summary. — The above observations seem to lead to the following general conclusions : (1) that the nemerteans inhabiting various species of crabs are distributed throughout the North Atlantic and into the Pacific Ocean, (2) that the New England form is identical with the long-known European species, (3) that several European forms thought to be widely different are either closely related or identical, (4) that *all* the species recorded show great similarity of structure, and may be closely related, (5) that the worms are true parasites and are not found except on the body of their host, spending practically their whole existence on the crab's body — in the gills when young, on the egg masses when mature, (6) that in different geographical regions the same species of worm may infest different species of crabs, (7) that the worms crawl about on the bodies of the crabs and are thus easily transferred from one host to another, (8) that by means of the free-swimming embryos the species may be distributed widely, although the young usually remain among the egg masses until they are past the free-swimming stage.

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ON THE ASEXUAL ORIGIN OF THE CILIATED SPONGE LARVA.

H. V. WILSON.

In 1891[1] and in 1894[2] I published certain observations which led me to believe that in monaxonid sponges free-swimming larvæ identical in structure with those developing from eggs are in some species produced asexually. For one such species, *Esperella fibrexilis* Wilson, the observations referred to are in brief as follows: (1) Parenchymal cells well supplied with yolk granules are found collected together in abundant small groups of varying size. Such groups have no definite shape and may contain few cells or many, and the component cells may lie together very loosely or be packed pretty closely.[3] The microscopic pictures indicate that the groups owe their origin to wandering cells that have collected together. (2) Rounded masses of similar cells are found, the cells tightly packed and polygonal in outline. To such masses, which are surrounded by a follicle composed of a single layer of flattened cells, I have applied the term "gemmule." The smaller gemmules are regarded by me as arising from the amorphous masses of parenchymal cells above mentioned, and the microscopic pictures further indicate that the gemmules grow both by cell divisions and by fusion with one another. The gemmules vary greatly in size. The smallest show *in section* only a few cells, the largest several hundred cells,[4] the diameter of the largest gemmules bearing to that of the smallest about the ratio of ten to one. With increasing size of the gemmule, the component

[1] Notes on the Development of Some Sponges, *Journ. of Morph.*, vol. v, No. 3.

[2] Observations on the Gemmule and Egg Development of Marine Sponges, *Journ. of Morph.*, vol. ix, No. 3.

[3] *Journ. of Morph.*, vol. ix, No. 3, Pl. XIV, Fig. 8; Pl. XV, Figs. 13–15.

[4] *Ibid.*, Pl. XV, Fig. 9, 5 cells; Fig. 16, 18 cells; Fig. 11, 37 cells; Fig. 9, about 60 cells; Fig. 21, about 100 cells; Fig. 18, several hundred cells.

cells are found to be more tightly packed, the fine yolk in the cell bodies is more abundant, and the nuclei are smaller. Hence, to demonstrate cell outlines in the largest (mature) gemmules[1] very thin sections are necessary. (3) Mature gemmules are found in which the compact mass of cells is broken up into a few large masses,[2] on the surface of which are semi-detached single cells, and between and round which lie scattered a few similar free cells. The shape and position of the partially free cells indicate that they are separating as individuals from the subsidiary masses into which the gemmule has broken. Gemmules in this stage are larger than in the mature undivided condition, the spaces between and round the subsidiary masses presumably being filled with absorbed fluid. (4) In other gemmules the subsidiary masses (always irregular in shape and of varying size) are numerous and small, and the free cells are abundant. (5) In yet another stage the constituent cells of the gemmule are found to be completely separated from one another, save that small multinucleate masses continue to be present. The cells of the outermost layer are flattened and form an investing membrane for the inner mass, the cells and multinucleate masses of which are connected together by delicate processes.[3] (6) Transitional stages show that the outer layer of cells becomes the surface epithelium of the larva, which is ciliated except at the posterior pole, while the inner mass becomes histologically differentiated into the several kinds of cells forming the parenchyma of the larva. The larva itself is a typical monaxonid larva, essentially identical in structure with those that are known to develop from segmenting eggs.

Thus an unbroken series of stages is found leading from a small mass composed of a few parenchymal cells to a ciliated larva. The various stages in this gemmule development, including the resulting larvæ, are scattered in great abundance throughout the sponge body, and their presence is associated with degeneration in the structure of the parent sponge. Nowhere in this continuous series of stages is an egg, either undivided or segmenting, interpolated. Very small ova, many

[1] *Journ. of Morph.*, vol. ix, No. 3, Pl. XV, Fig. 18.
[2] *Ibid.*, Pl. XVI, Fig. 21. [3] *Ibid.*, Pl. XVI, Fig. 22.

times less the diameter of the mature gemmule, are however present, although not common, in the parent parenchyma.

My conclusion that a larva, identical in structure with the typical egg larva of the group, is produced asexually in the manner just indicated has not seemed to certain reviewers (Maas,[1] Minchin[2]) altogether worthy of credence. And it may be that subsequent researches will show that such a conclusion is not necessitated by the facts. What I may point out here, however, is that the conclusion rests upon a series of microscopic pictures, the arrangement of which is left to the intelligence of the observer, and that this is precisely the kind of evidence on which rests our belief that in other sponges an egg development occurs. If, to be sure, the microscopic pictures (images) have been portrayed by me in an inaccurate fashion, then there is no need to consider the logic involved in their arrangement. This is in reality the point of view from which Maas has criticised my account, although he professes to find in my figures evidence for the correctness of his interpretations of them. Maas, in short, very freely and confidently expresses ('**93**, p. 370 ; '**96**, pp. 233–234) the belief that the bodies I figure and describe as gemmules are merely eggs surrounded by masses of nourishing cells ; and that the dissolution of the mature gemmule into subsidiary masses and ultimately into separate cells is only the segmentation of the egg. This process of dissolution specially awakens his incredulity : "Wie man es sich vorstellen soll, und welche Kräfte es bewirken sollen, dass ein Aggregat von Zellen, eine Gemmula, sich in einzelne Stücke weiter und weiter spaltet, darnach will ich hier nicht fragen, sondern nur darnach, warum Wilson in dem ganzen Vorgang nicht eine Furchung, in dem Auseinanderbrechen der Massen in kleine und kleinere Stücke nicht eine Zellteilung gesehen hat ! ?" ('**96**, p. 234). The mechanics of the process to me seem unworthy of so much wonder. Absorption of water by the

[1] Die Embryonal-Entwicklung und Metamorphose der Cornacuspongien, *Zool. Jahrb.*, Abth. f. Anat. und Ontog., Bd. vii, 1893 ; Erledigte und strittige Fragen der Schwammentwicklung, ***Biol. Centralbl.***, Bd. xvi, Nr. 6, 1896.

[2] The Position of Sponges in the Animal Kingdom, *Science Progress*, vol. i, N.S., July, 1897.

mass, coupled with the passage of individual cells from a resting condition, in which mutual pressure gives them a polyhedral shape, into an active condition would appear to be the essential features of the process and are phenomena not altogether outside our experience. Maas has obviously been led astray in his criticism by that well-known condition of mind in which things that are not familiar seem impossible. In a more open and receptive mood he would probably recognize the fundamental differences between the figures of gemmules shown in Pls. XV, XVI of my '94 paper and the figures of Fiedler[1] depicting the growth of the ovum in Spongilla, and would not attempt to explain the former as variations of the latter; more especially when in the same paper (Pls. XXIII, XXIV) I myself represent stages in the growth and segmentation of sponge ova (for Tedanione and Hircinia), the mode of growth in one species (*Hircinia acuta*) closely resembling that of Spongilla as described by Fiedler.

Since the publication of my results in 1894 there have appeared but two communications in which this question is touched upon, on a basis of actual observation. Vosmaer and Pekelharing[2] found in *Esperella ægagropila* certain reproductive bodies of a problematical nature. Not having at the time a sufficiently complete series of stages in the development of these bodies, they do "not enter into the question whether Wilson's statements about *Esperella fibrexilis* are applicable to our sponge." They confirm my observation that the formation of these "gemmules" is associated with degeneration in the structure of the parent sponge, which they find "entirely degenerates and finally dies off." The other communication is from Professor Ijima of Tokyo. This author in his recent beautiful and much admired work on the systematic zoölogy and histology of the Hexactinellida[3] reports observations in the main similar to mine, and is disposed to draw the same

[1] Ueber Ei- und Spermabildung bei Spongilla fluviatilis, *Zeitschr. f. wiss. Zool.*, 1888.

[2] Observations on Sponges, *Verhandelingen der Koninklijke Akademie van Wetenschappen te Amsterdam*, 1898.

[3] Studies on the Hexactinellida, Contribution 1, *Journ. Coll. Sci. Imp. Univ., Tokyo, Japan*, vol. xv, 1901.

conclusion with respect to the origin of the larva. Ijima's observations are as follows :

In *Euplectella marshalli* undifferentiated cells, styled "archæocytes," are found in abundance scattered through the sponge body. Such cells occur "solitarily or in irregular groups of two, three, and so on, up to tens and in certain positions even to hundreds or thousands." The growth of the archæocyte groups "may take place not only by cell division of their cells, but also by fusion of originally separate groups." The smaller groups are flat, the larger ones form solid and compact masses, the shape of which is at first rather irregular. "With continued increase in the number of the cells and consequently in the size of the mass, the latter assumes a roundish, oval or broadly lobose shape, measuring up to 100 μ or more across." Such masses are common in all large individuals. Ijima believes, on the strength of his own and earlier observations, that such congeries of archæocytes are of general occurrence in the Hexactinellida.

In certain archæocyte congeries the cells undergo a histological change, the cell body developing spherules and increasing in size. The transformed cells are known as "thesocytes." The spherules are not firm solids but are of a soft, perhaps even fluid, nature. Ijima concurs in the opinion of F. E. Schulze that the formation of spherules is a metabolic process analogous to the formation of glycogen in liver cells, and that the spherule substance is to be looked on as reserve nutriment. The substance of the spherules is probably of an albuminous nature. Ijima's description of the spherules strongly suggests that the bodies are comparable with the well-known *Glanzkörper* in the rhizopod Pelomyxa (see *Amer. Nat.*, Vol. XXXIV, No. 403).

All the archæocyte congeries are not transformed into thesocyte masses. Of those which are not so transformed, some possibly represent an early stage in spermatogenesis, but Ijima believes that "a good part of the primitive archæocyte congeries are directly and actively concerned in the formation of certain reproductive bodies, asexual or sexual but other than spermatozoa." The further history of such reproductive masses in *Euplectella marshalli* was, however, not followed. But Ijima

regards it as probable that similar masses constitute the anlages of the superficial buds known to occur in some hexactinellids (Rhabdocalyptus, Lophocalyx).

In two other species what appears to be the complete intraparental history of the archæocyte congeries was made out. But before describing Ijima's observations on these forms I wish to digress and point out how much commoner archæocyte masses seem to be in the Hexactinellida than ova and sperm. Ijima recalls the fact that very little is known concerning the ova and spermatozoa of these sponges. Schulze ('80, '87) describes sperm masses and ova (0.3 mm. in diameter) as present in more or less abundance, and usually in the same individual, in *Euplectella aspergillum.* Schulze was never able to discover any distinct segmentation stages. Ijima himself says: "It is somewhat surprising to me that, although the different hexactinellid species histologically studied by me are not few in number, yet scarcely a single case in which either of the sexual products was indisputably developed came under my observation." As regards the male elements Ijima says he is quite in the dark, that he has never seen spermatozoa or indisputable sperm masses, nor indeed does he feel disposed to say that he has seen ova. In one specimen of *Euplectella marshalli* a number of cells were observed, the larger ones measuring 10–15 μ, sometimes 23 μ, in diameter. Such cells are connected by transitional stages with, and are undoubtedly derived from, archæocytes. Ijima thinks these cells are young stages in the development of bodies similar to those described by Schulze as ova in *Euplectella aspergillum*, but does not commit himself to the view that they are eggs. In another sponge, a specimen of Leucopsacus, comparatively large spherical or ovoid cells, 20–40 μ in diameter, were found in some abundance. Such cells were not connected by transitional stages with archæocytes, and the describer again does not find the evidence for their ovum nature absolutely convincing. The fact that Ijima found no indubitable sexual elements is the more surprising since in the case of *Euplectella marshalli* he made special search for them, examining numerous specimens collected during the four seasons of the year. The rarity

of these elements suggests that the sexual breeding season of the Hexactinellida, *if it occurs annually*, is one of very short duration.

In the two species above alluded to, *Leucopsacus orthodocus* and *Vitrollula fertile*, Ijima has discovered not only archæocyte masses but also larvæ, the only hexactinellidan larvæ as yet observed. Reserving for a later contribution his detailed observations on these bodies, Ijima contents himself for the present with a sketch of their structure and development. The larvæ are spindle shaped, thicker at one end, and consist of a superficial flagellated layer covering an internal mass of cells. The hexactinellidan larva is thus fundamentally similar to that of monaxonid sponges. In an earlier stage the embryo is spherical in shape, with no discernible flagellation, and consists of a compact mass of small cells, those of the superficial layer showing an epithelium-like arrangement but not differing in general appearance from the internal cells. "At a still earlier stage there is found a simple cellular mass agreeing in all respects with the latter" (the stage just described) "except in having no distinct epithelial covering. And that simple cellular mass is in all appearance nothing else than an advanced stage of what I have called the archæocyte congeries, of which there exists a series of different sizes, leading down uninterruptedly to the little groups of cells so commonly found on the chambers. At all events, there is nothing else than these compact groups of small cells to which the origin of the developing embryo can be traced back with any degree of probability."

Ijima appreciates the remarkable character of the development just sketched and, before definitely formulating an opinion as to the asexual origin of the larva, wishes to continue his observations on a more plentiful supply of material than he has hitherto had. His position is best stated in his own words: "To repeat, to me it seems certain that the embryo in a very early stage of its development consists of a small assemblage of uniform-looking cells, which differ in no distinguishable feature from the archæocytes. If the resulting body were something comparable to a bud or gemmula, I would probably have felt no hesitation in concluding that the cells were really

archæocytes, and that we had here to do with a case of asexual reproduction. But, free-swimming larvæ, essentially similar to those developed from ova in other sponges, being at issue, the question whether true ova are not somehow complicated in the cell mass whence the larva arises seems to claim to be brought on the tapis, all the more, since our knowledge of the hexactinellidan ovum is far from being satisfactory." And again, p. 188, after mentioning my observations and conclusion, "I conceive the mode of origin and growth of the archæocyte congeries in the Hexactinellida to be just the same, and it seems to me not impossible that in the hexactinellid larvæ which I have seen we have simply a new case of the 'gemmule larva' or bud embryo." After referring to Maas's view that my conclusion rests upon a mistaken interpretation of a process of oögenesis, Ijima goes on to say with regard to his own observations, p. 189: "So far as concerns the archæocyte congeries of the Hexactinellida, I can confidently state that among the constituent cells in any stage of its growth, there exists not one which, on account of its size or of other external peculiarities, can be recognized as an egg. If it be that so many cells are aggregated for the sake of the nutrition of a developing ovum, this ovum is to be expected to deviate more or less morphologically from the rest as it approaches maturity; however, no sign of such a differentiation is noticeable. Further, all the cells in a congeries, large or small, are tolerably uniformly and compactly packed together, so as to directly touch one another; and where they are somewhat loosely arranged, there is not a trace of any substance between them. So that I am decidedly against the assumption that some of them are, at any stage of the growth of the congeries, engulfed among certain others as pabulum. If, after all that, a portion or all of the cells in a congeries giving rise to an embryo are still to be looked at in the light of blastomeres that have arisen by segmentation from a single egg cell, one is driven to the assumption that the original ovum is, like the blastomeres themselves, as small-bodied as, and indistinguishable from, an archæocyte. This would be very remarkable in an ovum; and moreover, under that supposition, it becomes imperative to deny

egg nature to the large ovum-like cells described by Schulze and by myself from Euplectella." Such an hypothetical mother cell of an embryo as Ijima suggests in the above excerpt would be something so different from an ovum that to class it as such, it seems to me, would be to confuse our ideas concerning reproductive cells. It would rather be analogous to a spore. However, both Ijima's observations and my own on the character of the smaller groups of archæocytes and their growth by fusion render unwarranted the assumption that any such cell exists, that is, as a typical and necessary condition in the development of an embryo. That a single cell may occasionally and incidentally give rise to a gemmule and so to an embryo is, of course, a possibility. And thinking over the possibility of such a case tends to clear up our ideas as to the nature of the typical reproductive archæocyte which acts in coöperation with others to form a new individual. If the hypothetical, exceptional archæocyte, which independently produces an embryo, is to be looked on as equivalent to a spore, the same view must be entertained regarding the typical coöperative archæocyte. In the one case we have a single spore producing the individual, while in the other case several spores unite, as, for instance, in the production of a myxomycete plasmodium (sporangium). Into the deeper-lying question as to how fundamental is the difference between an ovum and a spore there is no need to go. That there are, except in some of the plants, certain great and obvious differences no one will deny.

From a theoretical standpoint further investigations of this type of development in the sponges are much to be desired, and Professor Ijima's contribution will scarcely fail to call them out.

University of North Carolina,
December 20, 1901.

AGGREGATED COLONIES IN MADREPORARIAN CORALS.

J. E. DUERDEN.

PROF. G. VON KOCH,[1] in the eighth of his well-known "Kleinere Mittheilungen über Anthozoen," describes what he terms "Aggregated Colonies" as occurring in the simple Mediterranean coral, *Balanophyllia verrucaria*. The designation "aggregated" is employed by the author for such colonies as have been formed through the secondary fusion of individuals which were originally distinct, thus distinguishing them from most other Anthozoan colonies which are produced by the budding or fission of a single individual.

Von Koch collected around the small island of Vivara in the Mediterranean Sea a number of Balanophyllia which, instead of retaining the simple habit usual for this genus, consisted of two or more polyps. The corallites were fused with one another and possessed a common base, and many of the septa of adjacent calices were continuous. The tentacular system of each individual polyp was distinct, a mouth occurred in the center of each oral disk, but the column wall passed uninterruptedly from one polyp to another.

An examination of serial transverse sections of the corallum of two such colonies revealed that the corallites were independent towards the base, but united in a common secondary skeletal formation. In the case of a colony constituted of two individuals, one much larger than the other, von Koch concludes that the union had arisen through a larva settling near an older polyp; after the first skeletal rudiments were formed their coralla became fused through secondary deposition of calcareous matter, the larger polyp contributing most.

[1] Koch, G. von. Kleinere Mittheilungen über Anthozoen. VIII. Aggregirte Kolonien von Balanophyllia verrucaria Aut. *Morph. Jahrb.*, vol. xviii.

Sections of another colony, composed of four individuals, showed that the four corallites remained at approximately the same proportional size throughout, and the writer assumes that the mass was formed by four larvæ which settled close to one another and practically at the same time, each constructing its own corallum, and contributing an equal share to the formation of the common investing skeleton.

The late Prof. H. de Lacaze-Duthiers[1] has recently given an account of somewhat similar aggregations of the simple coral Caryophyllia, obtained from Port-Vendres. On many of the larger corallites smaller examples were growing, in such a way as to leave little doubt that the "bouquet" was a result of the adherence of Caryophyllia larvæ to the corallum of a polyp already established. Occasionally the individual members of a colony are polyps of practically equal size, as if originating from larvæ which settled simultaneously and in close proximity. In most of the examples described and figured by Lacaze-Duthiers the corallites retain their individuality, without the formation of a common secondary skeletal mass, but in one specimen (*loc. cit.*, Pl. XV, Fig. 12) two calices appear to have fused at their margin.

Prof. C. Schuchert has drawn my attention to the colonial condition generally exhibited by the rugose coral, *Streptelasma* (*Palæophyllum*) *divaricans* (Nicholson).[2] Representatives of the genus Streptelasma are usually simple, but numerous specimens of the above species in the collections of the United States National Museum, collected from near the top of the Lower Silurian of Ohio, constitute small colonies of two to six individuals. The colonies were at first supposed to have been formed "by lateral gemmation, or rarely by fission," but a close examination shows that such an explanation is very improbable. Each member retains more independence of form than is usual in colonies produced by gemmation or fission. In many instances two or more corallites are found adhering to some foreign object, such as a shell of *Rhynchotrema capax* or

[1] Lacaze-Duthiers, H. de. Les Caryophyllies de Port-Vendres, *Arch. de Zoöl. Exp. et Gen.*, Ser. 3, vol. vii, 1899.

[2] Geol. Surv. Ohio, Pal. II, 1875, p. 220, Pl. XXII, Figs. 10, 10 *b*.

a monticuliporoid bryozoan. The corallites of the different colonies vary greatly in size, but the members of any colony are practically equal, showing them to be derived from polyps of a similar age; there is no suggestion of a larger parent corallite and smaller buds. They seem best regarded as aggregated colonies.

The common West Indian coral, *Siderastræa radians* (Pallas), in the course of its development, has recently provided me with actual instances of colony formation by the fusion of originally free, distinct larvæ. The process of growth has been followed from the time of fixation of the free-swimming individuals as far as the production of the early skeleton.

Small, unfixed, adult colonies of *S. radians* occur in plenty in the shallow waters of Kingston harbor, Jamaica, and are easily kept alive in aquaria in the laboratory. The physiological activity of numbers of unicellular algæ, symbiotic within the endodermal tissues, renders unnecessary any artificial means of aëration of the water. Colonies are occasionally met with in which the internal cavity of many of the polyps is crowded with larvæ. These are shot out from time to time and are thus free to establish new colonies in turn. As a rule, only one or two larvæ are extruded at a time, but upon disturbance of a fully charged colony a score or so would appear together. In one colony the intermittent liberation of fresh individuals was continued for about a month.

Immediately on being set free within the water the larvæ were able to swim about, and revolved around their principal axis, being provided with a uniform layer of cilia. They measured two to three millimeters in length and were mostly pear-shaped, the narrow aboral end being anterior, or forward, in swimming. The broad oral end was posterior and dark colored, the latter condition owing to the presence of zoöxanthellæ (yellow cells) within the outer ectoderm. In a few larvæ the forward aboral end was the broader, as appears to be more usually the case in actinian and madreporarian larvæ when first extruded. The majority were opaque, without any outward indication of internal mesenteries, but occasionally a distended specimen was met with in which the walls were

nearly transparent and revealed eight internal mesenterial divisions.[1]

During the first day the Siderastræa larvæ remained near the surface of the water or gathered around the sides of the vessels in which the colonies were kept. Afterwards they traversed the water as a whole, though some preferred the neighborhood of the bottom of the vessel. From the first day many would sink to the bottom and there lie motionless for a time, after which the swimming movements might recommence.

By the evening of the second day a few individuals had fixed themselves permanently, either to the sides or bottom of the vessels, or to the foreign objects partly incrusted by the parent colonies. At first the larvæ would adhere by means of the actual tip of the narrow extremity, but this would soon flatten out and form a broad base, a small rounded oral aperture appearing at the free extremity. Whether or not any individual larva would settle seemed very uncertain, for out of several hundreds set free comparatively few became permanently fixed. If fixation were not accomplished within the first few days it seemed to be impossible afterwards. In one instance about a score of larvæ were isolated, and nearly all kept alive for a period of twenty days, without any of the specimens settling, although various suitable objects were placed in the vessels.

Fig. 1.

While many larvæ fixed themselves isolated from others, a decided disposition to settle simultaneously in small groups was evident. Thus in Fig. 1, where three larvæ are represented, all in the first stage of fixation, their narrow apices are so close as to be nearly touching. It is clear that when they

[1] The larvæ of West Indian corals are usually set free at a stage at which three or more pairs of mesenteries are already developed, the stomodæum fully formed but non-functional, and the interior wholly, or in part, occupied by a highly vacuolated tissue. After liberation the stomodæum becomes functional, the larva enlarges, its walls become more transparent, and much of the vacuolated tissue breaks down and is seen to be extruded at intervals through the oral aperture.

flatten out by this extremity their walls will be in close contact, and a colony of three young polyps will result.

Such a colony, adherent to a pebble, and formed of seven individuals, is represented in Fig. 2. The drawing was made two or three days after fixation of the larvæ, when the adult polypal form was beginning to be assumed, and the tentacles were just appearing as rounded prominences. All the polyps are at practically the same stage of development, proving that they settled synchronously, or nearly so. They are irregularly arranged with regard to one another, and in their effort to fully

FIG. 2.

expand the walls press upon one another, and produce distortion of the proximal part of the column.

To the under surface of another small pebble thirty-eight larvæ attached themselves in groups of two, three, or more. One of these groups contained a dozen or so young polyps, all touching, the mutual pressure producing an angulation of the normally circular base. Another group of thirty-two became adherent during a single night to the surface of a small glass dish. In this case nearly all the members, upon flattening, were touching to a greater or less degree.

Fixation having taken place, the larvæ, now to be regarded as polyps, seemed remarkably vigorous, and underwent the next stages of development with comparative rapidity. In

sharp contrast with this the unfixed larvæ remained all the time at practically the same stage as when first extruded.

The glass vessel to which some of the polyps became adherent was broken into small fragments, with the polyps still upon them. These could then be transferred from one aquarium to another, or examined in small dishes as transparent living objects under the microscope. In this way the growth of the various organs was followed day by day. Some specimens were kept alive for a period of seventeen weeks, the development of the tentacles and septa being followed as far as the third cycle. For the present purpose the normal development will be succinctly reviewed, so as to compare the modifications introduced as a result of the primary grouping of many of the polyps in colonies.

On fixation the tissues of the polyps became transparent and the six pairs of primary mesenteries were seen to be already present, four pairs attached to the stomodæum and two pairs incomplete. About a month elapsed before the members of the second cycle began to appear, being first represented by a pair in each of the dorsal exocœles, then later by a pair in each of the middle exocœles, and finally by a pair in each ventral exocœlic chamber.

The first tentacles commenced to make their appearance two or three days after settling, as six rounded outgrowths over alternate mesenterial chambers, and early showed an opaque, white, knob-like apex distinct from a short, more transparent stem. The six prominences appeared simultaneously, constituting a first cycle, and were equal in size and distance apart, and in communication with the exocœlic chambers. About four weeks passed before another cycle of six tentacles appeared, internal to the first, and situated over the entocœlic chambers. The further tentacular development was somewhat complicated and need not be here considered.

Three or four days after fixation the skeleton was first observed in the form of six radiating septal upgrowths, practically equal in size. At the same time a narrow peripheral calcareous ring was formed, its outer surface uncovered by the soft polypal tissues, and therefore to be regarded as an epitheca.

The six septa were free from one another and from the epitheca, and situated at equal distances apart within the primary entocœlic chambers, thus alternating with the cycle of six exocœlic tentacles first to arise.

A day or two after the formation of the first cycle of entosepta the six exocœlic septa began to make their appearance, in some cases simultaneously, but successively in others, in bilateral pairs from the dorsal to the ventral aspect of the polyp.

Under ordinary transmitted light no basal skeletal formation could be detected, but with polarized light the presence of crystalline particles could be demonstrated. In polyps macerated at this period a very thin basal disk was recognizable,

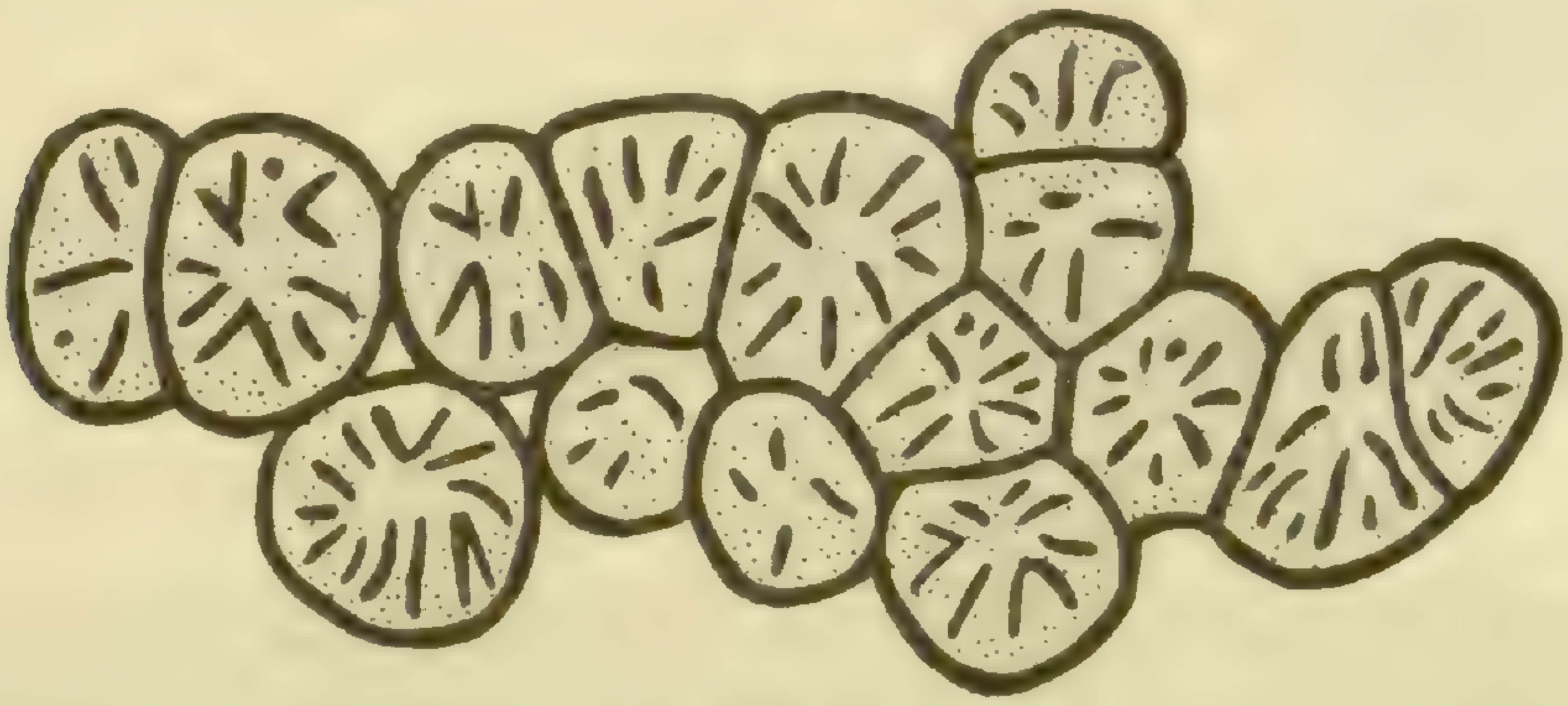

FIG. 3.

formed of an aggregation of irregular granules, and continued at its edge as the upturned epitheca, the six or more radial septa arising from it vertically some distance within.

A wide range of variation was exhibited by the different polyps as to the rate of growth of the various organs, especially in the later stages. The individuals which were larger on fixation soon outstripped the others; scarcely any succumbed, and it was possible to feed them on fragments of worms and mollusks.

Such a regular, symmetrical development was characteristic only of the isolated polyps, free to expand equally on all sides. The polyps in groups were crowded to such a degree as to necessitate arranging themselves at all angles with regard to one another and the incrusted object. Sometimes part of the base of one polyp would be reclining against part of another; but none of the individuals seemed to be overpowered by such

close proximity. As a whole, the growth of the colonial polyps was much less forward than that of the isolated specimens. All were normal as regards the occurrence of the six pairs of primary mesenteries—four complete and two incomplete; the tentacles also were represented by a primary cycle of six exocœlic representatives and a secondary inner cycle of six entocœlic members. Variations and irregularities, however, were introduced in connection with the formation of the skeleton. The epitheca was invariably produced at the free basal edge of the column wall, and under such conditions as those represented in Fig. 2, it is clear that its outline would be irregular, and that the epitheca of one polyp would be in contact with that of the contiguous polyps to the extent the polypal walls were adherent. Likewise the basal disks of two polyps reclining against one another would be formed at a sharp angle.

The septa of the colonial polyps exhibited from the beginning many irregularities and imperfections. Such a series is indicated in Fig. 3. The drawing was taken from the under surface of a living colony of seventeen polyps, adherent to a fragment of glass, and viewed by transmitted light, so that only the basal skeletal structures are exhibited. The polyps are seen to vary greatly in size; the outline is angulated where they are in contact with others, and rounded on the free border. The two larger polyps at each extremity of the colony partly overlap one another at an angle, though this is not very obvious from their flat basal expansions alone. The thickened margin to each polyp represents the epitheca, that of two contiguous polyps being fused along the line of contact. The basal disk is yet so thin as to be practically transparent and is indicated by the dotted areas.

The radiating dark bands, as a rule simple, but sometimes forked, represent the adherent surface of the septa; the latter on account of their vertical thickness are non-transparent like the epitheca. In no polyp are the two orders of six septa fully or regularly developed in the manner already described for isolated polyps. Any number of septa from four to twelve are represented, as a rule with a suggestion of alternating large and small members.

The development of the colonial polyps was not followed far beyond the stage represented in Fig. 3. Growth was very slow compared with that of the isolated individuals, and most were preserved for further study. There was no indication, however, but that under favorable natural conditions the aggregations would have grown into fully mature colonies. In the later stages the primary irregularities due to crowding would probably have been outgrown, and the groups would then present all the characters of normal colonies arising by budding.

In one feature the polyps constituting an ordinary colony of *S. radians* differ from those in a colony formed of aggregated, primarily independent units. Polyps arising by gemmation are, as a rule, only incompletely cut off from the parent; their internal cavities are from the beginning in communication with those of the adult polyps, so that the nutrient fluid can circulate from one individual to another. Such would not be the case at first with aggregated colonies, and at the very early stage at which the observations on Siderastræa were made I could not assure myself that intercommunication was established. The intervening external epitheca would for some time interfere with such a possibility, but no doubt this structure, along with the basal plate, would be left behind in the upward growth of all except the marginal polyps. For, except a most rudimentary formation at the margin, the epitheca is absent from mature colonies.

It does not seem probable that the phenomenon of aggregated colonies is a prominent feature of coral growth. Still, it is necessary that its possibility should be recognized, for wherever it occurs the resulting colony will probably differ somewhat from one produced by normal budding or fission, while when occurring in usually simple corals its non-recognition might lead to disastrous results.

All students of both fossil and recent corals are familiar with the fact that very often simple coralla are found adhering to the dead portions of colonies, undoubtedly the young of these. Among West Indian corals the occurrence of young polyps under such conditions is very frequent in *Manicina areolata*

(Linn.) and *Favia fragum* (Esper). A colony of Manicina will sometimes possess five or six adhering young polyps, the different members of which exhibit one, two, three or more oral apertures, and in other ways are regularly developed. Their structural details prove that they have originated not by fission or budding, but from larvæ which have settled, probably immediately or shortly after extrusion, in close association with the parent colony. Colonies of Manicina and Favia are often found charged with larvæ, and their extrusion has been frequently observed.

Much variation exists as to the activity displayed by the larvæ of these and other coral species immediately on extrusion. In some cases the larvæ are quite vigorous, and able to swim about from the beginning; and under natural conditions these would no doubt continue their activities for a long time, and might be drifted great distances before settling. Others again sink immediately on liberation from the interior of the parent, and falling upon the nearest object may settle there. In most instances the nearest object will be the dead lower part of the parent colony. It is thus easy to see how, under ordinary natural conditions, such aggregations as those found by von Koch and Lacaze-Duthiers may have arisen. The grouping of the larvæ in *S. radians* appeared to be less fortuitous than this, for practically all the specimens were able to swim about immediately on being set free. It may be that the tendency towards aggregation above described was in some way influenced by the cramped artificial conditions of the small aquaria.

The possibility of extruded larvæ settling in numbers immediately around the parent, instead of drifting widely apart, is a phenomenon likewise to be looked for in the field study of the closely allied Actiniaria. On the coral reefs in West Indian waters occur large irregular patches, often several feet across, of one or other of the anemones, *Actinotryx sancti-Thomæ* Duch. & Mich. and *Ricordea florida* Duch. & Mich. The polyps are usually adherent to some dead coral slab, and in a single patch there may be hundreds of individuals. Both species exhibit asexual reproduction by fission, and in any

group are to be found specimens with from one to three or more oral apertures on a single disk. One may assume that all the individuals constituting a patch have arisen asexually from one or a few primary polyps. But such does not appear to be the case. Aggregations have been observed in which one large example would be surrounded by a number of others, all smaller but practically uniform in size. Both species are found to extrude larvæ very freely, and there seems no doubt that the patches are in the main formed of individuals derived from such larvæ as settled near the parent. A certain number of fission polyps would also be expected. Externally it would be practically impossible to distinguish between larval polyps and fission polyps, but the internal mesenteries afford distinctive characters as to the one or the other form.

Similar extensive patches of the large discosomid, *Stoichactis helianthus* (Ellis) are not infrequent. Their occurrence is probably to be explained in the same manner as above, that is, as due almost entirely to the aggregation of distinct larvæ. Asexual reproduction seems to be very rare in this species.

Polyps of the northern species of Metridium usually occur in groups. From the researches of G. H. Parker[1] and others, asexual reproduction seems to play a considerable part in the crowding habit of these, but the possibility of aggregating larvæ also should not be overlooked, even though *M. marginatum* extrudes unfertilized eggs.

Johns Hopkins University,
Baltimore, Md.

[1] Parker, G. H. Longitudinal Fission in Metridium marginatum Milne-Edwards, *Bull. Mus. Comp. Zoöl. Harvard*, vol. xxxv, 1899.

UTAH CHILOPODS OF THE GEOPHILIDÆ.

RALPH V. CHAMBERLIN.

In this paper are presented descriptive accounts of six new species of chilopods belonging to the genera Geophilus and Linotænia, four to the former and two to the latter. The material upon which the descriptions are based was collected for the most part during the spring and summer seasons of 1901. By way of showing the position of the new forms in their genera analytical keys are given for the species here first described and also those known previously from the western United States.

Key to Western Species of Geophilus.

a_1. Frontal plate discrete; last ventral plate wide.

b_1. Anal pores present; pleural pores numerous; pairs of legs 53–55 (♀); length 50–53 mm. . . . *glaber* Bollman

b_2. Anal pores absent; pleural pores two; pairs of legs 47–53; length 37–47 mm. . . . . . . *cephalicus* Wood

a_2. Frontal plate not discrete; anal pores present.

b_1. Last ventral plate relatively narrow.

c_1. Claw of anal legs obsolete; pleural pores ten or eleven; basal plate free; pairs of legs 73 (♂); length 39 mm. *occidentalis* Meinert

c_2. Claw of anal legs long; pleural pores eighteen or twenty; basal plate partly covered; pairs of legs 73–75; length 49–55 mm. . . . . . . *nealotus* sp. nov.

c_3. Claw of anal legs short or indistinct; pleural pores nine; pairs of legs 45–49; length 20–31 mm. *xenoporus* sp. nov.

c_4. Pleural pores thirty or more; basal plate partly covered; pairs of legs 64–67 (♀); length 36 mm. *californiensis* Bollman

b_2. Last ventral plate relatively wide.

c_1. Claw of anal legs obsolete; basal plate thrice wider than long; pleural pores partly covered; coxæ of prehensorial feet armed; length 29 mm. (♀) . . . *atopus* sp. nov.

c_2. Claw of anal legs short; basal plate four times wider than long; pleural pores free; coxæ of prehensorial feet unarmed; length 40–43 mm. . . . . . *glyptus* sp. nov.

Geophilus nealotus sp. nov.

Description. — Rather robust, very gradually attenuated anteriorly, more strongly posteriorly; prosternum and head with a few long hairs or subglabrous, the latter partly granular or mostly smooth, polished, the body nearly glabrous, smooth and polished; head light chestnut or brown, body dorsally light brown to yellow, ventral plates and legs yellowish, antennæ the same or darker.

Antennæ rather short (4.4–4.6 mm.); the four basal joints sparsely pilose with long hairs, the others closely clothed with finer short hairs; joints all long, the ultimate much shorter than the two preceding taken together.

Cephalic plate much longer than wide (5 : 3.8 nearly); posterior border truncate; impressed with two lateral and a single median sulcus, the latter within a more or less evident longitudinal furrow, which is wider and shallower anteriorly; covering the anterior border of the basal plate; basal plate large, subequal to the first dorsal scutum, 2.5 times wider than long.

Claws of prehensorial feet when closed reaching to the distal portion of the first antennal joint: each claw with a small obtuse tooth at base; coxa armed with an inconspicuous obtuse tooth; sternum wider than long, more than twice the outer height of the coxa, anterior border widely sinuate, unarmed.

Dorsal scuta with a single median and two lateral longitudinal sulci, which become obscure on a few of the first middle plates but are again distinctly impressed caudad: often a few of the last middle scuta with a transversely oval or oblong depressed and darker colored area marked off anteriorly and posteriorly by a crescentic impression; anterior præscuta very short, gradually increasing in size to the first posterior segments, which are moderate, then more rapidly decreasing to end of body.

Anterior spiracle very large, vertically oval or suboval, a few following of the same shape, others round; decreasing in size from the first to the last, caudad becoming very small.

Ventral scuta with a median longitudinal sulcus, which may be faint or quite absent on a number of the middle plates, its place there being taken by two more or less distinct lateral sulci; a median suboval or somewhat triangular poriferous area on posterior portion of each plate; with sometimes but one, but more commonly with two, transverse furrows, these on each side often broken up into several lines diverging toward the middle of the plate.

Legs sparsely pilose; first pair distinctly shorter and more slender than those following; anterior pairs stouter and shorter than posterior pairs; anal legs much longer than the penultimate, moderately swollen, each provided with a rather long claw.

Posterior pleuræ inflated, with 18–21 subseriate pores on each side, the few innermost covered by the last ventral plate; last ventral plate

relatively rather narrow, its sides very gently curved convexly (♀) or concavely (♂), converging posteriorly; anal pores moderately large.

Pairs of legs of male seventy-three, of female seventy-five. Length of male 55 mm., width 1.6 mm.: length of female 49 mm., width 1.5 mm.

Adolescens. — A specimen 30.5 mm. long measures .7 mm. in width; length of antennæ 2.6 mm.; pleural pores very small, eight on each side; pairs of legs the normal number (75); coloration as in adults.

Habitat. — Under stones in the gullies of the hillsides north of Salt Lake City.

The types were collected March 28, 1901.

Geophilus xenoporus sp. nov.

Description. — Moderately robust, distinctly attenuated caudad and cephalad; head and prehensorial feet sparsely pilose with long or moderately long hairs, cephalic plate punctate, especially at sides, with moderately coarse punctæ, the prosternum and coxæ of prehensorial feet sparsely minutely punctate, dorsal and ventral plates nearly glabrous, smooth or a little roughened; head and prehensorial feet with prosternum light brown, body, legs, and antennæ yellow.

Antennæ rather short (♂ 1.6–2 mm., ♀ 2.4–2.5 mm.); first seven or eight joints sparsely pilose, the others, especially the final ones, densely clothed with short straight hairs; articles all long, the ultimate subequal to the two preceding taken together.

Cephalic plate much longer than wide (7 : 5 nearly), narrowed posteriorly; posterior border somewhat rounded, covering the basal plate anteriorly; with two rather long lateral sulci and a brief but sharply impressed median line immediately caudad to the frontal suture; basal plate rather large, width about three times the middle length, the plate being more exposed laterally.

Claws of prehensorial feet when closed reaching or a little surpassing the distal end of the first antennal article; claw armed at base with a long subacute tooth; inner side of coxa long, armed similarly to claw but tooth somewhat stouter; prosternum nearly equal in length and breadth, less than twice the height of the coxa, the anterior border narrowly and acutely incised, unarmed.

Dorsal scuta bisulcate, the sulci distinct throughout: anterior præscuta short, the middle long or very long, the posterior moderate.

First spiracle longitudinally oval, the others circular, not much decreasing in size caudad, all small.

Ventral plates with a median sulcus which is deep, especially cephalad.

Legs sparsely pilose; the first pairs shorter and much more slender than those succeeding; the anterior pairs stouter than the posterior but not much differing in length; anal legs of male much swollen, those of the female more slender, with a short or indistinct claw in the male, longer in the female.

Pleuræ of last segment not much inflated, with about nine small pores on each side, these arranged along a suboval line on ventral and lateral surfaces; last ventral plate narrow, the sides straight and parallel; anal pores small.

Pairs of legs of male 45, of female 47–49. Length of male 19–21 mm., width .5–.6 mm.; length of female 30–31 mm., width .9–1 mm.

Adolescens. — Specimens 13 mm. long measure .4 mm. in width; length of antennæ 1.2 mm.; pleural pores four or five on each side; color pale yellow.

Habitat. — Canyons near Salt Lake City, mostly among decaying leaves and in vegetable mold.

The types were collected in City Creek Canyon, April 1, 1901.

Geophilus atopus sp. nov.

Description. — Rather slender, very gradually attenuated cephalad, more strongly caudad, depth of the body in the middle region as great as the width; head sparsely pilose, smooth, the basal plate and exposed dorsal portion of prosternum more densely covered with hair, the dorsal scuta mostly very sparsely clothed with short hairs, not at all roughened; cephalad light brown, head a little darker at sides, caudad yellowish, antennæ and legs concolorous with adjacent parts of body.

Antennæ short (2 mm.); the first three or four joints sparsely pilose with moderate straight hairs, the others more closely clothed with short hairs which increase in density to ultimate joint; ultimate article nearly equal in length to the two preceding taken together.

Cephalic plate much longer than wide (5 : 4 nearly); anterior and posterior margins truncate; with two distinct lateral sulci and a fine discontinuous median line; frontal border of basal plate concealed, exposed portion thrice wider than long.

Claws of the prehensorial feet when closed reaching to the middle of the first antennal article; claw armed at base with a pale obtuse tooth; coxa armed similarly to claw; prosternum wider than long (9 : 8 approximately), less than twice the height of the coxa, anterior margin with only a shallow sinus, unarmed.

Dorsal scuta with two rather faint lateral sulci and a single median sulcus, these more strongly impressed caudad; first dorsal præscuta short, irregularly increasing in length to the posterior region, where they are long excepting the last few, which are very short.

The first anterior spiracle subround, those following round, gradually decreasing in size caudad, finally becoming small or very small.

Ventral scuta faintly sulcate, the anterior ones with a median depressed area posteriorly on the plate; ventral pores large, arranged over and about the depressed area, extending forwards and backwards along the median line and laterally to the sides, farther caudad the pores mostly restricted to

a transverse band; posterior border of the anterior scuta produced backwards from the sides to the middle, there touching or slightly overlapping the succeeding plate, exposing the præscutum of the latter only at the sides; posterior borders of plates after the twenty-second straight.

Legs, excepting ultimate, pilose with moderately long straight hairs; first pair more slender than others, not much shorter; anterior pairs much stouter than the posterior, not much shorter; anal legs much swollen, claw obsolete, clothed more densely and, more often, with shorter hairs than pairs preceding.

Pleuræ of last segment not much inflated, with about twelve pores of several sizes, these arranged subseriately, partly covered by the last ventral plate; last ventral plate wide, much wider than long (1.8.5 : 1), sides convexly curved, converging posteriorly.

Pairs of legs of male 69. Length of male 29 mm., width .7 mm.

Habitat. — The type specimen, a male, was found buried in damp sawdust under a piece of timber, Salt Lake City.

The type was taken June 3, 1900.

Geophilus glyptus sp. nov.

Description. — Body robust, caudad strongly, cephalad but little attenuated; head pilose at sides, more especially posteriorly, basal plate and exposed dorsal portions of prosternum more densely pilose, prosternum ventrally subglabrous, first dorsal plates sparsely provided with short hairs, the plates caudad becoming subglabrous, ventral plates glabrous; head and prosternum with the prehensorial feet chestnut, body above and below amber brown, or in middle portions yellowish, legs and antennæ concolorous with the body.

Antennæ short (3–3.4 mm.), stout, attenuated from base distally; first four or five joints sparsely provided with long hairs, the others with shorter hairs, which decrease in length and increase in density toward ultimate article; articles long, the ultimate shorter than the two preceding taken together.

Cephalic plate a little longer than wide (9 : 8.2 nearly): posterior margin truncate, anterior margin extending forward from the sides to the middle, sides rounded, impressed with two lateral and a single median sulcus; basal plate partly covered, exposed portion over four times wider than long.

Claws of prehensorial feet not much curved, when closed reaching to or a little beyond the distal end of the first antennal article; each claw armed at base with a moderately small obtuse tooth: inner side of coxa short or very short, unarmed; prosternum wider than long (not quite 9 : 8), over twice the outer height of the coxa, anterior margin widely sinuate.

Dorsal scuta impressed with two lateral and a single deep median sulcus; anterior præscuta very short, middle long or very long, posterior short.

First two anterior spiracles very large, round, those following abruptly smaller, also round, gradually decreasing in size caudad, in the middle and posterior segments very small.

Ventral plates with a median sulcus which is strongly impressed cephalad, becoming rather faint caudad.

Legs all pilose; the first pair much smaller than those succeeding; anterior pairs much stouter and also longer than the posterior; anal legs long, moderately to strongly swollen, armed with a short or very short claw.

Last pleuræ moderately inflated, with about twelve pores which are subseriate and free, or sometimes a few covered by the last ventral plate; last ventral plate moderately wide (♂) or narrower (♀); anal pores present, moderate in size.

Pairs of legs of male 67, of female 69. Length of male 43 mm., width 1.3 mm.; length of female 40 mm., width 1.2 mm.

Adolescens. — Specimens 30 mm. long measure .8 mm. in width; proportionately wider cephalad than adult; length of antennæ 2.6 mm.; pleural pores seven or eight on each side; coloration nearly as in adults.

Habitat. — Along the streams in the canyons near Salt Lake City.

The types were collected in Neff's canyon, Salt Lake County, June 30, 1900, by my brother, Mr. Seth C. Chamberlin.

KEY TO WESTERN SPECIES OF LINOTÆNIA.

a_1. Pairs of legs 71–81; individuals large.

b_1. Pairs of legs 71; length 60 mm., head not punctate or spotted. *parviceps* (Wood)

b_2. Pairs of legs 81; length 140 mm., head minutely spotted with white. *epileptica* (Wood)

a_2. Pairs of legs 37–47; individuals small. (Frontal plate discrete, anal pores present, last ventral plate wide or moderate.)

b_1. Anal legs shorter than the penultimate; pleural pores 5–7, moderate; posterior border of cephalic plate straight; pairs of legs 39–41; length 13.5–16.7 mm. . . . *miuropus* sp. nov.

b_2. Anal legs longer than the penultimate; pleural pores 7–11, small; posterior border of cephalic plate triangular; pairs of legs 43–47; length 20–21 mm. . . . . . *micropus* sp. nov.

Linotænia miuropus sp. nov.

Description. — Robust, gradually attenuated caudad, more strongly cephalad; head and entire body moderately or subdensely clothed with short hairs, smooth; ferruginous, ventral plates and legs paler.

Antennæ short (maximum length 1.2 mm.); moderately hirsute, decreasing in density distally, ultimate article subglabrous, hairs short or very short; first articles of medium length, shorter distally, the ultimate longer than the two preceding taken together.

Cephalic plate wider than long; posterior border covered by the basal plate, substraight; impressed with a median sulcus; frontal plate discrete; basal plate in male less than thrice wider than long (2.8 : 1 nearly), in female more than four times wider (4.35 : 1).

Dorsal scuta not sulcate; anterior præscuta short, middle and posterior moderately long.

Ventral plates with a distinct median sulcus.

Spiracles all round, the first rather small, those succeeding scarcely decreasing in size, the posterior being not much or not at all smaller than the anterior.

Legs sparsely hirsute with moderately long hairs; first pair distinctly smaller than others; the anterior and posterior pairs subequal; anal legs of male shorter than the penultimate, much stouter, densely clothed with short hairs, armed with a slender claw, anal legs of female slender, not at all swollen, similarly hirsute to other legs.

Pleuræ of last segment with 5–7 moderate pores on each side; last ventral plate relatively intermediate in width, wider than long (6.7 : 5.7 nearly), sides curved, converging posteriorly; anal pores moderate.

Pairs of legs of male 37–39, of female 41. Length of average male 16.7 mm., width .9 mm.; length of female 13.5 mm., width .65 mm.

Habitat. — About a dozen specimens were found in Logan canyon, Cache county, near the mouth, and three were taken among the pines on the divide between Daniell's Creek and Hobble Creek canyons, Utah county.

The types were collected May 25, 1901.

Linotænia micropus sp. nov.

Description. — Robust, cephalad strongly, caudad more gradually attenuated; head and body above and below pilose, more densely in female than in male, last ventral segments more densely pilose than others, prosternum nearly glabrous (♂) or sparsely hirsute (♀); ferruginous throughout.

Antennæ very short (1 mm.), stout; moderately pilose; articles mostly short, the ultimate longer than the two preceding taken together.

Cephalic plate as a whole subequal in width and length, exposed portion wider than long in the ratio of 6 : 5.4; posterior border produced backwards from sides to middle, subtriangular, overlapped by the basal plate: basal plate thrice wider than long.

Claws of prehensorial feet when closed not reaching the front margin of head by a considerable space; claw armed at base with a long stout tooth, coxa unarmed; prosternum much wider than long (7 : 4.2 approximately), two and one-half times longer than the coxa, anterior margin widely sinuate, unarmed; inner margin of coxa extremely short or entirely concealed.

Dorsal scuta not sulcate; anterior præscuta short, longer in male than in female, the middle and posterior moderately long.

Ventral plates with a single median sulcus which caudad becomes indistinct or obsolete, with a transverse furrow or depression; excepting the first few, with a rather large median poriferous area on the anterior portion of plate, this often, especially caudad, prolonged backwards in the form of a narrow tongue; ventral pores also arranged on each side of the sulcus in front of the posterior border.

Anterior spiracle intermediate in size, those succeeding very gradually decreasing, caudad becoming small.

Legs pilose with mostly rather long hairs; first pair distinctly reduced, the second pair intermediate; anterior and posterior pairs not much differing in size; anal legs of male strongly swollen, densely clothed with short to very short fine hairs, longer than the penultimate, anal legs of female not at all swollen, similarly pilose to other legs, armed with a short pale claw.

Pleuræ of last segment with 7–11 small obliquely seriate pores on each side; last ventral plate wide, sides curved, strongly converging posteriorly, anterior border produced forwards from sides to middle line, making the plate subpentagonal; anal pores present.

Pairs of legs of male 43–47, of female 47. Length of average male 21 mm., width 1 mm.; length of female 20 mm., width 1.2 mm.

Adolescens. — Specimens 12.5–13.5 mm. long measure .4–.6 mm. in width; length of antennæ .6–.7 mm.; pleural pores 4–6 on each side; color yellowish or light brown.

Fetus. — One individual examined is still coiled up within the egg, the yellowish outer membrane, or shell, of which, however, is evenly split down one side from end to end, the thin transparent inner membrane being still intact; in this condition the egg is spherical and measures 1 mm. in diameter.

An individual 4 mm. long is free excepting posterior segments, these still covered by the membranes; legs short and rather stumpy, closely crowded; antennæ bent back under the head along the not yet fully formed mouth parts.

Specimens 4.5–7.5 mm. in length still spirally coiled; width .4 mm. and under; antennæ extended, as usual relatively long, clavate, joints very short excepting the ultimate, the latter as long as the three or four preceding taken together; color brownish.

Habitat. — In the quaking aspen and pine woods along the head waters of Manti and Pole canyons, San Pete County, and about the glacial lakes at the head of Little Cottonwood canyon, Salt Lake County.

All the specimens of the fetus stage, ten in number, were found together with the body of the female coiled about them, the nest being a pit in the underside of a log.

The types were collected in Pole canyon, July 15, 1901.

Latter-Day Saints' College, Salt Lake City,
December 17, 1901.

ON THE COLOR VARIATIONS OF THE COMMON GARTER SNAKE.

EDWIN C. ECKEL.

I. Eutænia sirtalis in the Adirondack Region of New York.

In an earlier paper[1] I have noted that Cope's treatment of the color forms of *Eutænia sirtalis*, at least so far as the subspecies occurring in the northeastern United States are concerned, can hardly be regarded as satisfactory. My acquaintance with the extreme western and southern forms of the species is entirely too limited to permit the expression of an opinion on the closeness with which his subspecific grouping, in those areas, approximates to the facts; but it seems probable that the same conditions prevail there as here.

In a catalogue[2] (now in press) of the reptiles and batrachians of New York, prepared by Dr. F. C. Paulmier and myself at the request of Dr. F. J. H. Merrill, director of the New York State Museum, no revision of Cope's grouping was attempted. All the subspecies described from this state by Cope and G. M. Allen were included, as it seemed undesirable, in a paper designed for popular use, either to omit these forms without presenting reasons for such action, or to discuss these reasons in the necessary detail.

For this reason the results of the collection work which has been accomplished during the past year, in critical localities, are presented in this paper.

My thanks are due to Dr. F. C. Paulmier, who has kindly placed the resources of the zoölogical department of the State Museum at my disposal, and to Mr. Raymond L. Ditmars, who

[1] Snakes of New York, *Amer. Nat.*, February, 1901.

[2] Paulmier, F. C., and Eckel, E. C. Catalogue of the Reptiles and Batrachians of New York, *Bulletin New York State Museum.*

has given me many facts regarding the distribution of the various color forms of the common garter snake.

It is to be regretted that the results so far obtained are chiefly negative, tending to cast doubt upon the tenability of previously described subspecies, without pointing out the direction in which we are to look for more significant variations. A large series of living specimens, collected in such widely separated areas as the Adirondacks, the Catskills, the Hudson Highlands, Long Island, the shore of Lake Ontario, and the counties of the "southern tier," might indicate the presence of certain variations which could be correlated with differences of habitat, or are associated with such other aids to polytypic evolution as would justify us in considering them as subspecies. It is hardly necessary to say that, for the purposes of this study, living specimens are absolutely essential. Colors alter so rapidly on immersion in alcohol that alcoholic specimens are worthless so far as color variations are concerned.

1. *Subspecies previously described from the Adirondacks.*

The subspecies of *Eutænia sirtalis* which have been noted as occurring north of Pennsylvania are as follows : *E. s. graminea* (Cope), *E. s. ordinata* (Linn.), *E. s. sirtalis* (Linn.), *E. s. obscura* (Cope), and *E. s. pallidula* (Allen). Of these, all save *E. s. graminea* have been found in the Adirondack region. In the present paper I purpose discussing the effect, upon the tenability of the subspecies *E. s. obscura* and *E. s. pallidula*, of the examination of material collected in New York state during the past field season. In a future paper I hope to discuss the remaining subspecies. The characters of *E. s. obscura* and *E. s. pallidula*, as given by Cope and Allen respectively, are as follows :

Eutænia sirtalis obscura (Cope).

Cope, in his last discussion[1] of this subspecies, describes it as a form in which the spots have entirely (or almost entirely)

[1] Cope, E. D. Crocodilians, Lizards, and Snakes of North America, *Rep. Nat. Mus.* (1898), p. 1074.

disappeared by fusion, leaving the stripes intact. The coloration above is therefore deep brown or almost black, with three yellowish stripes, of which the laterals are less distinct than the dorsal. The gastrosteges are grayish green, with the usual black spots near the ends.

In this subspecies he includes one specimen from Mitchell's Bay, Ontario; three from Lac qui Parle, Minnesota; and five from Westport, Essex County, New York. These last were collected by Baird and described[1] by him as *Eutænia sirtalis.*

The specimens assigned to the subspecies are, it is true, all from northern localities, but no definite statement is made as to the range of the form; and it is probable that Cope did not intend to associate this coloration with any particular area or life zone. A proposed subspecies, based upon specimens from widely scattered localities (the intervening areas being occupied by other subspecies), is, in general, to be regarded with suspicion, unless positive evidence, other than that afforded by similarity of coloration, can be adduced in favor of its subspecific value. Positive evidence of this character is rarely obtainable, particularly in the case of reptiles. In the case now under discussion, I believe that it can be shown that *obscura* intergrades completely with more typical forms of *Eutænia sirtalis*; that its color characters cannot be correlated with any particular climatic conditions; and that therefore individuals exhibiting these color characters cannot be regarded as subspecifically distinct from those showing the coloration of typical *Eutænia sirtalis.*

Eutænia sirtalis pallidula (Allen).

In 1899 G. M. Allen described[2] the subspecies *pallidula* from specimens taken near Intervale, N. H., giving its geographic distribution (p. 64) as "from the White Mountains of New Hampshire and the Adirondacks of New York northward into New Brunswick and Nova Scotia, and possibly farther." Later in the same paper (p. 65) he states that

[1] Baird, S. F., and Girard, C. *Catalogue of North American Reptiles* (1853), p. 31.

[2] Notes on the Reptiles and Amphibians of Intervale, N. H., *Proc. Bost. Soc. Nat. Hist.* (1899), p. 64 *et seq.*

pallidula is the characteristic form of the Canadian zone, and restricts "the name *Thamnophis sirtalis* Linn. to the brighter-colored form found in the Transition and Austral zones of the east." This restriction necessitates a redescription of *Eutænia sirtalis sirtalis*, which he accordingly gives. His summary of the differences between the two subspecies is as follows: "*Thamnophis sirtalis pallidula* needs comparison with no other of the *sirtalis* group except *T. sirtalis* proper, from which it differs in the obscurity of the dorsal stripe, which is grayish, not yellow; the ground color, which is olive brown, not black or blackish; in the chestnut color below the lateral stripe, where *sirtalis* is olive; in the lighter color of the belly, especially in the younger examples; and in the interlinear spots as previously described" (*i.e.*, the spots of *pallidula* were described as being composed of chestnut scales, with black edges and interspaces, and those of *sirtalis* proper as being composed of scales usually entirely black, occasionally faintly reddish in the middle).

As can be seen, this is an attempt to correlate a certain variation with a given "life zone"; and, if justified by the facts, would be a distinct advance upon the subspecific treatment of Cope. For this reason the question of its validity requires a more detailed discussion, for even a slight variation — if obviously arising from definite causes — is worthy of consideration. As will be seen later, however, I cannot admit that *pallidula* fulfills these necessary conditions. Not only do the characters assigned to it occur frequently in specimens outside of the Canadian zone, but all specimens from that zone do not exhibit these characters.

2. *Specimens collected during 1901 in New York State.*

Specimens from Moody, Franklin County, N.Y.

1. Dorsal stripe very faint, but still visible on close examination as a dull yellow-brown line. Lateral stripes fairly well shown; greenish yellow. Sides below lateral stripes brownish green. Gastrosteges greenish; black spot on anterior edges, near sides, often communicating by a thin black band along

anterior edge of the scutum with the lowest row of spots. Color, above lateral stripes, olive green. Interspaces (between scales) light greenish. Spots present, but not very marked. Scales composing spots chestnut, with black edges and interspaces.

Second upper labial on right side divided; left side normal. First temporal on both sides of head divided, its anterior portion appearing as a small separate triangular plate.

2. Dorsal stripe fairly distinct, lateral stripes less so. Sides below lateral stripes dark green. Gastrosteges greenish. Color above lateral stripes olive green; interspaces light greenish. Spots present, composed of chestnut scales, with black edges and interspaces.

3. Dorsal stripes almost invisible; lateral stripes fairly well shown. Sides below lateral stripes brownish. Gastrosteges greenish. Color above lateral stripes olive brown; interspaces light greenish. Spots very indistinct (owing to brownish background), composed of chestnut scales, with black edges and interspaces.

4. Dorsal stripe visible but not distinct. Lateral stripes visible; yellowish. Sides below lateral stripes light brown. Gastrosteges greenish. Color above lateral stripes olive brown; interspaces light greenish. Spots of chestnut scales, with black edges and interspaces.

5. Dorsal stripe almost invisible, only showing on close examination. Indications of lateral stripes on second and third scale rows; yellowish. Sides below lateral stripes light brown. Gastrosteges slate gray, tinged brownish. Color above lateral stripes olive brown; interspaces light greenish. Two rows of spots between lateral and dorsal stripes; the scales, in general, being black (a few, however, are chestnut, with black edges), with black interspaces. Another series of spots, similar in color, along the first and second scale rows.

6. Dorsal stripe visible throughout; yellowish. Lateral stripes faint. Sides below lateral stripes light brown. Gastrosteges slate gray. Other colors as in No. 5.

7. Dorsal stripe visible. Lateral stripes very faint. Sides below lateral stripes brown. Gastrosteges grayish, tinged with

brown. Color above lateral stripes olive brown. Interspaces light greenish. Spots of chestnut scales, with black edges and interspaces. Preocular divided on right side; left side normal.

8. Dorsal stripe very faint; lateral stripes faint. Color above lateral stripes brown, tinged olive. Interspaces light greenish. Four series of spots between lateral stripes. Scales of the spots chestnut, with black edges and interspaces. The four series connect across back, forming bars or network. Top of head deep green. Chin and throat orange. Rostral yellow. Lower labials white, tinged yellowish on upper edges. Upper labials yellow to yellowish green, black edges anteriorly. Sides below lateral stripes, together with exterior portions of gastrosteges, brown. Remaining portions of gastrosteges olive brown. Lower side of tail deep orange.

9. Dorsal stripe pure and rather deep yellow near head, becoming browner yellow and somewhat less distinct posteriorly. Lateral stripes yellow, rather distinct. Color above lateral stripes olive brown; interspaces light greenish. Spots present, not very distinct; composed of chestnut scales, with black edges and interspaces. Sides below stripes brown; gastrosteges lighter brown.

10. Dorsal stripe yellowish brown, distinct throughout. Lateral stripes brighter and somewhat more yellowish than the dorsal. Color above lateral stripes brown, tinged olive. Interspaces light greenish. Spots composed of chestnut scales, black borders and interspaces. Sides below stripes, as well as exterior edges of gastrosteges, a soft light brown. Remaining portions of gastrosteges greenish gray.

To the descriptions of these specimens from Moody, Franklin County, N.Y., I will add for comparison descriptions of a few other living specimens of *Eutænia sirtalis* examined this year:

11. *Sconondoa Creek, one-half mile east of Oneida, N.Y.* Dorsal stripe not apparent. Lateral stripes faint, but visible; yellowish brown. Sides below lateral stripes brown. Gastrosteges greenish. Ground color above lateral stripes dark olive brown. Spots present, but not apparent against the dark background.

12. *Same locality.* Dorsal and lateral stripes distinct, yellow. Sides below lateral stripes, and gastrosteges, greenish. Spots distinct. Ground color above lateral stripes olive brown.

13. *Rensselaer, Rensselaer County, N.Y.* Dorsal stripe conspicuous throughout; clear yellow. Lateral stripes fairly distinct. Sides below lateral stripes brownish green; gastrosteges dark greenish. Ground color above lateral stripes very dark brown, almost black. The location of the spots, on this dark background, is only indicated by the blackness of their interspaces, the normal interspaces being light greenish.

14. *Rochester, N.Y.* Dorsal stripe fairly conspicuous. Lateral stripes indistinct. Ground color above lateral stripes soft olive. Spots of chestnut scales, with black edges and interspaces.

15. *Ausable Forks, Essex County, N.Y.* Dorsal stripe dull yellow brown, but fairly distinct. Lateral stripes faint. Sides below lateral stripes brown. Gastrosteges brownish green. Ground color above lateral stripes dark greenish brown. Spots indistinct.

16. *Same locality.* Dorsal stripe very faint; dull dark brown. Lateral stripes visible; yellowish brown. Sides below lateral stripes dark brown. Gastrosteges grayish green. Above lateral stripes dark olive brown. Spots indistinct because of darkness of ground color; composed of scales only a little redder than the ground color, with black interspaces.

17. *Same locality.* Dorsal stripe rather faint; dull brown. Lateral stripes very faint. Sides below lateral stripes brownish green. Gastrosteges greenish. Ground color above lateral stripes greenish olive. Spots small and indistinct; composed of chestnut scales, with black edges and interspaces. Eight superior labials on each side resulting from the division of the (normal) second upper labial. Lower anterior portion of prefrontal plates on each side divided, so as to give, in effect, two loreals, one above the other.

The following table gives certain data concerning the localities from which the specimens in the above list were obtained. In the cases of Moody, Rochester, Oneida, and Rensselaer the elevations given are those of the exact collecting localities.

Concerning the other localities I have no exact data as to the collecting range, and have therefore given the geographic position and elevation of the villages.

DATA CONCERNING LOCALITIES DISCUSSED.

	Locality.	Elevation. A. T.	Latitude.	Longitude.
1	Moody, Franklin County, N.Y.	1600′	44° 12′	74° 30′
2	Intervale, N.H.	546′	44° 15′	71° 25′
3	Ausable Forks, Essex County, N.Y. . . .	600′	44° 26′	73° 41′
4	Westport, Essex County, N.Y.	271′	44° 11′	73° 29′
5	Rochester, Monroe County, N.Y.	280′	43° 12′	77° 36′
6	Oneida, Oneida County, N.Y.	440′	43° 06′	75° 39′
7	Rensselaer, Rensselaer County, N.Y. . .	60′	42° 38′	73° 44′

The specimens from Franklin County, N.Y., were collected by me during August, 1901, at Moody, a small settlement on the east shore of Tupper Lake. All the specimens from that locality described above (Nos. 1–10) were obtained at an elevation of about 1600 feet A.T. Though the ophidian fauna of the Adirondacks appears to be scanty, so far as species are concerned, the few species occurring within the region are represented by numerous individuals. The specimens above described were not selected because of color, but are simply those which reached the museum alive and in good condition. The locality is, of course, well within the Canadian life zone, and the specimens can therefore be compared directly with those described by Allen from Intervale, N.H.

As can be seen from the descriptions given (Nos. 1–10), the specimens obtained from this one small area furnished fairly good examples of three of the four subspecies credited to the Adirondacks, together with specimens intermediate between each pair of the three. If we omit the specific and higher characters, there is hardly one point in which the ten specimens agree. The dorsal stripe is, in most, somewhat indistinct; but in one specimen it is quite bright throughout, and in others barely visible. In color it varies from dull brown to yellow — never gray or grayish. The spots are usually of chestnut scales, with black edges and interspaces; but the chestnut

areas may be very small and only faintly reddish. The distinctness of the spots varies with the ground color. In one specimen the sides below the lateral stripes are dark green; in another, brownish green; in the remaining eight specimens, various shades of brown. In two specimens various characters have aided each other in such a way as to give a fairly uniform reddish brown coloration above the lateral stripes, thus even going a step beyond the condition shown by Cope's *Eutænia sirtalis obscura*. The gastrosteges vary in color from greenish gray to slate gray or even brown.

The general darkness of color is much accentuated by the age, not necessarily of the individual, but of the skin which the specimen is wearing at the time of examination. Six of the specimens brought from the Adirondacks have shed their skins since their arrival at the State Museum. Four of these had been examined with some care previous to this time, and reëxamination after shedding developed the fact that, while the markings are unchanged, the colors are sufficiently brightened by shedding to produce an impression of much lighter tint.

To sum up these statements, I find that ten specimens of the common garter snake obtained (by an unmethodical selection) from an area less than two acres in extent, located well within the Canadian life zone, represent, according to the criteria of various authors, the following subspecies:

	Number of Specimens represented.		
According to	*E. s. sirtalis.*	*E. s. obscura.*	*E. s. pallidula.*
Baird	10	—	—
Cope	8	2	—
Allen	—	—	7[1]

The specimens (Nos. 15, 16, and 17) collected by Mr. Van Allen Lyman near Ausable Forks, Essex County, N.Y., which is also within the Canadian life zone, exhibit similar variations.

[1] Three of the ten specimens show characters agreeing with neither of Allen's descriptions; the remaining seven would probably be accepted by him as *pallidula*, though few of them exhibit *all* the characteristics of that form.

The thirteen specimens so far discussed prove that the Canadian life zone contains garter snakes not exhibiting the characters of *pallidula*. An examination of the descriptions of specimens 11, 12, 13, and 14 (all of which are from points in the Transition or Upper Austral zone) will show that specimens exhibiting the characters of *pallidula* are not confined to the Canadian zone. It would seem impossible, therefore, to agree with Mr. Allen in assuming any relation between the characters of *pallidula* and the climate of the Canadian life zone. As a matter of fact, specimens exhibiting these characters may be found in almost any part of New York state. I believe that at the present time Mr. Ditmars has, in the New York Zoölogical Garden, living specimens of this type captured in New York City.

If, however, no relation can be established between the coloration of the form *pallidula* and any particular habitat, *pallidula* can no longer be regarded as a definite variation from the type, due to definite climatic conditions. It then falls to the same level as the form *obscura*, and apparently no reason can be given for assigning subspecific rank to either.

New York State Museum,
December 5, 1901.

CONTRIBUTIONS FROM THE ZOÖLOGICAL LABORATORY OF THE MUSEUM OF COMPARATIVE ZOÖLOGY AT HARVARD COLLEGE. E. L. MARK, DIRECTOR. NO. 133.

NOTES ON THE DISPERSAL OF SAGARTIA LUCIÆ VERRILL.

G. H. PARKER.

STUDENTS of the New England sea anemones have for some years past been acquainted with a small but striking species of Sagartia that inhabits, often in great numbers, the higher tidal pools and similar situations on our coast. This sea anemone is about a quarter of an inch in height, slightly less in diameter, and of a dark green color; it is usually striped vertically with a few orange lines and has a cluster of some forty-eight whitish tentacles. It was described nearly four years ago under the name *Sagartia luciæ* by Verrill (**'98**), who first observed it in 1892 and annually after that for six seasons near New Haven. On the authority of W. R. Coe, Verrill reports it common at Woods Hole in 1898. He suggests that it may have been introduced into the region about New Haven on oysters that are annually brought from the south in large quantities and planted in the waters of Long Island Sound. He notes its rapid increase in numbers. That it is multiplying and spreading considerably is indicated by the following records of earliest occurrences, which, though probably open to revision, give a rather definite idea of the direction and rate of dispersal. When not otherwise stated, these records are based on the observations of the writer.

New Haven, Conn. Verrill, who for a long time has been especially acquainted with the marine invertebrates of this region, states that he did not observe this species between 1865 and 1890. His attention was first called to it in 1892 by Miss L. L. Verrill, who found it in tidal pools at Outer

Island, Conn. It was then much less abundant than in 1898, when it was described.

Newport, R.I. This anemone was not found in the region about the Newport Marine Laboratory in 1887, nor in 1890, though in both seasons the actinians of the Newport region were extensively collected. In the summer of 1895 it was the most abundant species in the cove next the laboratory.

Woods Hole, Mass. *S. luciæ* was not observed by Verrill in his very exhaustive study of the fauna of Woods Hole between 1871 and 1887. In my own collecting at that place in 1889 it was not obtained. It was reported from Woods Hole in 1898 by W. E. Coe, and, in a letter to me from T. H. Morgan, the same year is given as the earliest at which Professor Morgan is certain of its occurrence in that locality. It is now abundant on the wharves about Woods Hole, and especially on the eel-grass in the Eel Pond.

Nahant, Mass. This species was not found at Nahant between 1882 and 1898, though collections of invertebrates from this locality were made usually several times annually in the years between 1882 and 1898. In the autumn of 1899 a few specimens of *S. luciæ* were found in a small high tidal pool on Little Nahant. During the summer of 1901 Albert P. Morse, without knowledge of the previous occurrence of this species at Nahant, collected specimens of it in that locality. It is now very abundant in most tidal pools on Little Nahant.

Salem, Mass. It was collected at Salem Neck, near Fort Pickering, and near the Salem end of the Beverly Bridge in the summer of 1901 by Albert P. Morse.

Salem is the most northerly locality for which I have any record of the occurrence of this species, and, since it is not included in the Preliminary Catalogue of the Marine Invertebrates of Casco Bay, Me., prepared a year ago by Kingsley ('01), it may be that Salem is not far from its present most northerly limit.

The five localities already mentioned fall into the following series when arranged according to the sequence of earliest occurrences: New Haven (1892), Newport (1895), Woods Hole (1898), Nahant (1899), and Salem (1901). This series shows,

I think, beyond a doubt that the species has migrated eastward from New Haven and northward to Salem, having covered the distance between these two extremes probably within ten years. As this actinian is remarkably hardy, thriving well in high tidal pools where the water is often temporarily much diluted and very variable in temperature, it is unlikely that the change from the warmer waters south of Cape Cod to the colder ones north of that point will noticeably retard its dispersal. Like the introduced periwinkle, *Littorina littorea* (see Bumpus, '98), this species will probably gain an extended distribution both north and south of Cape Cod, though in this instance the invasion comes from the south instead of from the north, as with the periwinkle. It is hoped that these notes will call the attention of observers to *S. luciæ*, so that definite information may be obtained as to its present distribution, both north and south, and likewise evidence of its further dispersal.

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'98. The Variations and Mutations of the Introduced Littorina. *Zoöl. Bull.* Vol. i, pp. 247–260.

Kingsley, J. S.

'01. Preliminary Catalogue of the Marine Invertebrates of Casco Bay, Me. *Proceedings of the Portland Society of Natural History.* Vol. ii, pp. 159–183.

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'98. Descriptions of New American Actinians, with Critical Notes on Other Species, I. *Amer. Journ. of Sci.* Ser. 4, Vol. vi, pp. 493–498.

NOTES AND LITERATURE.

BIOGRAPHY.

Lamarck's Life and Work.[1] — It would be difficult to single out from the naturalists of the past one more appropriate for biographical treatment at the present time than Lamarck. The renewed interest taken in his work in the last two decades, and the appearance of such books as Darwin's *Life and Letters* and the recent biography of Huxley suggest some extended treatment of the greatest of the precursors of the Darwinian movement. Unfortunately, the material for such a study is meager in the extreme, and Dr. Packard has been obliged to search assiduously for the relatively few facts he can record of the life of the great French naturalist. The biographical portion of the work is contained in the first sixty-five pages. Then follows a general estimate of Lamarck by contemporary and later biologists. Lamarck's wide range of activities is next reviewed in chapters dealing with his work in meteorology and physical science, in geology, in invertebrate paleontology, in general physiology, in botany, and in zoölogy. This is followed by a historical treatment of the theory of evolution leading up to Lamarck's contribution to it. The last chapter is on Neolamarckism, and the volume is concluded by a bibliography and a short index. There are ten full-page illustrations, four of which are portraits of Lamarck.

The biographical chapters, which really form the introduction to the body of the work, give one the impression of uncritical methods. Dr. Packard was unable to find in Paris any exact statement of Lamarck's birthplace, and he undertook the very worthy task of seeking it out for himself. His belief, however, that the house that he was shown at Bazentin was the place in question rests upon the unsupported statement of the village schoolmaster, who, we are told, left his duties in the schoolroom to point out the ancient structure. Possibly Dr. Packard may be correct, but the whole account has much more the air of French politeness than of scientific acumen. Still more unsettling are the statements concerning

[1] Packard, A. S. *Lamarck, the Founder of Evolution, his Life and Work.* New York, Longmans, Green & Co., 1901. xii + 451 pp., 10 pls.

Lamarck's death. This occurred, according to Dr. Packard, on Dec. 28, 1829 (p. 56), the obsequies were celebrated on the Sunday preceding December 23, the burial took place December 30 (p. 57), and the first assembly of professors after his death was on December 22 (p. 62). From this confusion of dates one may seek refuge in a biographical dictionary to find that Lamarck died December 18 and was buried probably December 20. It is really unfortunate that in the one extended account of Lamarck's life in English the date of his death should not be accurately recorded.

Although the biographical introduction is somewhat disappointing, the body of the work more than makes good this defect. Dr. Packard is to be congratulated on having hit upon the happy idea of allowing Lamarck to expound his own views, and a large part of the 300 pages that follow the biography is made up of translations of well-selected passages from the works of Lamarck. Nowhere else in English is one likely to find so true an exposition of the *Philosophie zoologique* as in the chapter devoted to this subject, and the reading of this portion of the work is to be recommended to every student of zoölogy that is not already familiar with Lamarck's original publications.

The concluding chapter deals with Neolamarckism, a movement with which Dr. Packard has had much to do and about which he can consequently speak with authority. The impression made by this chapter is, however, one of extreme vagueness. What Neolamarckism is, is nowhere made very clear. Darwin's views and Lamarck's are contrasted, and much stress is laid on the importance of environment as a factor in the production of variations; but the idea is not even suggested that all such material may be only grist for the Darwinian mill. Moreover, a strange inconsistency runs through much of this chapter, for Dr. Packard seems to think that by pointing out the weaknesses of Darwinism, he is strengthening Lamarckism. This leads him to give numerous quotations from the works of eminent biologists who were keen enough to expose some of the weak points in natural selection, but who did not perceive that by so doing they were ranking themselves Neolamarckians. The last quotations in criticism of natural selection are taken from Huxley; had a few been drawn from Darwin the proof would have been complete. The real question, however, is not whether Lamarckism is true and Darwinism untrue, — for these theories are not necessarily incompatible, — but what are the factors of evolution; and on this point Dr. Packard has not much to say, though in

the body of the work Lamarck tells us many things worthy of careful perusal and thought. While this last chapter, like the biographical introduction, leaves much to be desired, Dr. Packard's volume is so replete with good translations of well-chosen passages from Lamarck that one cannot hesitate in pronouncing it the most complete and truthful statement of Lamarck's views that has thus far appeared in English.

ZOÖLOGY.

Benham on Flatworms. — The present volume,[1] which is Part IV of Lankester's *Treatise*, is the third of this useful series to make its appearance, and covers, in Chapters XIV to XXI inclusive, the Turbellaria, Temnocephaloidea, Trematoda, Cestoidea, Appendices to the Platyhelmia, and Nemertini. Each chapter opens with a synopsis of the classification adopted for the group, and this is followed by an admirable historical summary, which, though brief, is notably clear, complete, and well balanced. The next section deals with the general characters of the group under consideration, and contains an analysis and discussion of each subdivision in order, closing with a list of the chief works on the group. The "ideal" platyhelminth, exploited in the opening chapter, is rather too generally used to meet the approval of present-day zoölogists, even though it affords an easy standard of comparison for the beginner. It is a great pleasure, however, to see some important theoretical explanations presented in a general text, and that in a clear and attractive manner which serves to make the mass of detail comprehensible. But it may be seriously questioned whether anything is gained by raising to the rank of phylum every group which after intensive study appears to be sharply set off from its nearest of kin.

For Turbellaria the author has used the classification of Lang and von Graff, and has made a happy selection of figures to illustrate the points under consideration. The short chapter on Temnocephaloidea follows Haswell's work very closely and gives the best presentation of this little-known group accessible in any text-book.

Among the Trematoda, Monticelli's classification, as modified by

[1] *Treatise on Zoölogy.* Edited by E. Ray Lankester. Part IV, The Platyhelmia, Mesozoa, and Nemertini. By W. Blaxland Benham, D.Sc., M.A. London, Adams and Black; New York, The Macmillan Company. 204 pp., 114 text-figs.

Braun, has been adopted in the main, although such minor changes as those in the arrangement of the families will hardly be regarded by most helminthologists as an improvement. A few minor errors have crept into the chapter, as the representation (Fig. IX) of the lateral nerve as the chief longitudinal stem, and the denomination of the basement membrane as an internal limiting cuticular membrane.

The classification used for the Cestoidea is a combination of those used by Braun and Lang, to the former of which it is certainly inferior. The use of *Cestoidea merozoa* instead of *Cestoidea polyzoa* Lang is a noteworthy improvement as avoiding the confusion and incorrect inference in the latter term; but why not a single term rather than the cumbersome double form? The arrangement of the families is open to the criticism that no grouping can be considered more than temporary which is based on so artificial a feature as the number of suckers. Both text and literature are deficient in respect to the older work of Cohn and Lühe, and one is struck by the entire omission of references to the very extensive and important work of Stiles, although one cut was taken from Stiles and Hassall.

The next chapter, which is referred to on the title-page and in the preface as dealing with Mesozoa, distinctly repudiates that term and considers as separate appendices to the Platyhelmia the Rhombozoa, Orthonectida, Trichoplax, and Salinella. An extended note by the editor of the series adds here a valuable statement of recent results of importance which would have been welcome in other places also.

The final chapter, dealing with Nemertini, follows the work of Bürger closely. Two pages of addenda and corrigenda have been added by Mr. Punett without doing more in the opinion of the reviewer than emphasizing the unfortunate delay in the appearance of the book. Scant justice is done some authors, and as striking a paper as that by Woodworth on Planktonemertes is entirely passed over.

There are some features which appear rather clumsy in American eyes, such as the use of Roman numerals to designate the figures, and the habit of beginning to number the figures anew in each chapter. One may justly say also that the figures are inferior to such as are used in this country to-day, and far behind those found in continental texts. As instances of the use of mediocre figures for forms of which good representations are easily accessible may be cited those of Bothriocephalus (p. 112) and Echinococcus (p. 131), while that of Dipylidium (p. 135) is little more than a caricature.

Much of the poor effect of the figures may be attributed to the author's inclination to use ideal or diagrammatic representations.

It is difficult to criticise fairly a work which, as the editor of the series says in a prefatory note, was written in 1897 and was entirely in proof in 1898. The epoch-making work of Looss on Trematoda and of Cohn and Lühe on Cestoidea, as well as many shorter contributions, have added so largely to our knowledge of these groups that what was thoroughly good in 1898 would now be strikingly out of date. One cannot help wondering how the work could have been held so long unpublished. In spite of these disadvantages, it will stand as a clear and well-balanced presentation of the subject, admirably arranged and suggestive in treatment.

HENRY B. WARD.

Structure and Metamorphosis of Actinotrocha. — In the *Journal of the College of Science of the Imperial University of Tokyo, Japan*, Ikeda[1] gives an account of studies on the development of Phoronis, from the unsegmented egg through the metamorphosis. For the earliest stages, the author was able to obtain living material in quantity, of the species *Phoronis ijimai*, while the structure of the larva was studied in four species (or forms) of Actinotrocha taken in the region of the Misaki Marine Biological Station.

The author gives some interesting details as to the life history of Phoronis, showing that the adults probably die every year, the colonies being completely replaced by the metamorphosing larvæ. He criticises the present classification of the species of Phoronis, holding that several of the so-called species are not really distinct.

A detailed account is given of the cleavage, gastrulation, formation and structure of the larva, and the transformation into the adult. Ikeda's results on some important or disputed points are as follows: The formation of the mesoblast begins at the beginning of gastrulation, by the irregular pushing of some of the entoblast cells into the cavity of the blastula. Mesoblast formation continues in the same manner from the two "anterior diverticula" of the archenteron, and from a ventral groove leading backward from the blastopore. The mesoblast cells are at first irregularly scattered, and only later arrange themselves to form the boundaries of the body cavities. The latter are thus not formed from enteric diverticula, as has sometimes been

[1] Ikeda, Iwaji. Observations on the Development, Structure, and Metamorphosis of Actinotrocha, *Journ. Coll. Sci. Imp. Univ. Tokyo, Japan*, vol. xiii, pp. 507–592, Pls. XXV–XXX.

described. The posterior so-called "anal pit" is said by Ikeda to be the *Anlage* of the nephridia, and to have no connection with the so-called "primitive streak." In many details Ikeda's results differ from those of Masterman, — especially in many of the points which the latter emphasizes as indicating affinities with the Diplochorda. Thus, Ikeda considers as artefacts, due to reagents, the oral and pharyngeal grooves which Masterman had compared with gill slits, the "neuropore," the "subneural gland," and certain parts of the vascular system described by Masterman. He was further unable to find the "proboscis pores" of Masterman, the "trunk nephridia," the ventral blood vessel, the dorsal mesentery, the collar nerve ring, the ventral nerve commissure, or the perianal nerve ring. The impression is thus given that his results are largely opposed to those of Masterman; the latter, however, points out in a recent review[1] of Ikeda's paper that in regard to the fundamental structure of Actinotrocha the points of agreement are more important than those of disagreement; indeed, he claims Ikeda's work as a corroboration of his own.

Ikeda has given especially valuable observations on the relation of the body cavities and vascular systems of the adult to those of the larva, — a complex matter, on which little had been done, and which perhaps requires still further elucidation. The vascular system of the larva is very simple as compared with that of the adult, not forming a closed system at all; the transformation of the one into the other in the fifteen or twenty minutes occupied by the metamorphosis is therefore a complicated matter. In the same way the body cavities of the larva and adult by no means correspond. Ikeda states that the collar cavity of the Actinotrocha is largely transformed into the "ring vessel" of the adult, — the collar cavity of the latter being largely a new formation. H. S. J.

A General Course in Insect Anatomy.[2] — This is a new edition of a little book that is important both of itself, and because it represents the fundamental laboratory course in the chief center of entomological instruction in America. The book has been evolved along with the laboratory which it represents, and each new edition marks progress in the knowledge of even those subjects which are dealt with in the most elementary instruction.

[1] *Quart. Journ. Micr. Sci.*, vol. xlv (1902), pp. 485–492.

[2] Comstock, J. H., and Kellogg, V. L. *The Elements of Insect Anatomy: An Outline for the Use of Students in Entomological Laboratories.* Ithaca, Comstock Publishing Co., 1901. 145 pp., 11 figs.

The changes to be noted in this edition are not very extensive. External anatomy is studied in grasshopper and beetle; internal anatomy, in the larvæ of Corydalis and Holorusia; there are two chapters devoted to comparative anatomy of mouth parts and wings; there is a brief opening chapter on terminology, and another concluding one on methods of insect histology. The growth of eleven pages is chiefly due to the (new) chapter on the anatomy of the larva of the giant crane fly (Holorusia) by Professor Kellogg. This chapter, proposed as an alternative to the one on Corydalis, is a very desirable addition whether Corydalis be obtainable or not. Such statements as this, "The internal anatomy of all insects is exceedingly similar," continue to be repeated in the latest text-books of zoölogy; but it would seem that even the average "pure morphologist," for whom one grasshopper constitutes an entomological summer, should eventually learn their absurdity.

In the old chapters there are new paragraphs here and there. In the study of even such well-worn subjects as the skeleton of the grasshopper the discovery of new sclerites still goes on. Thus, in the last edition were noted for the first time *sternum* and *sternellum*, and in this one we note such new parts as *trochantin of the mandible* and *antennary sclerite*, etc.

For a simple, straightforward, condensed guide to the laboratory study of elementary insect anatomy, there is no such book elsewhere.

J. G. N.

The Breeding Habits of Cancer magister. — In 1884 Prof. J. Brown Goode wrote[1] concerning *Cancer magister*: "Nothing is known regarding the spawning season and habits of this species. The occurrence of a female with spawn in the San Francisco market has not yet been recorded by any naturalist." This last statement is still true, there being no scientific record, so far as I can learn, of the capture of this crab while it was carrying eggs. This is rather remarkable, since *Cancer magister* is the largest of the edible crabs of the Pacific coast of the United States, and extends from Sitka on the north, as far as Magdalena Bay, Lower California, to the south. In San Francisco Bay and vicinity they are common, and thousands are annually brought to the markets, where they hold as important a position as does Callinectes in the commerce of the eastern seaboard.

[1] *The Fisheries and Fishery Industries of the United States.* Section 1, Natural History of Useful Aquatic Animals. 1884.

On the 29th of December, 1900, two females carrying eggs were sent to the zoölogical department of Stanford University by Mr. J. B. Babcock of the California State Fish Commission. These were procured in the market and had been caught in San Francisco Bay. The eggs of one of these were in various stages of gastrulation, while the others were older, showing slight pigmentation of the eyes. During the following summer, while aboard a fishing steamer off the California coast, I was shown six females "in berry." In one of these the embryos were half-developed zoëas, and the young of another were only slightly more advanced, while the remaining carried larvæ almost ready to burst their membranes. The captain of the vessel stated that he had taken egg-bearing females in every month of the year, and that the "yellow eggs" (young stages) occurred from the first of October until some time in January. This statement is supported by the discovery of seven other females taken off Moss Landing in Monterey Bay during January, 1902. All these carried eggs, which were in various stages, ranging from late gastrulation to half-developed zoëas. It thus appears that the breeding season of *Cancer magister* commences in the late summer or during the autumn and usually continues until some time in the following summer. H. H.

Pratt's Invertebrate Zoölogy.[1] — This new book by Professor Pratt of Haverford College consists of a series of directions and descriptions for the guidance of students in their laboratory work in connection with comparative anatomical study of invertebrated animals. The types for study are selected from the following groups and in the order named: insects, myriapods, Crustacea, annelids, platyhelminths, Bryozoa, mollusks, ascidians, echinoderms, Hydrozoa, sponges, Protozoa. Several types from each of the important phyla are treated, and thus within groups the practical study is made truly comparative. This is important, for such comparisons as untrained students can make for themselves are necessarily limited in the usual series of types with a single representative of each important phylum. Another valuable feature of these practical directions is that each lesson is complete in itself, so that the sequence of types may be varied at the will of the teacher. This is also of advantage in selecting the exercises of which the book contains more than ordinarily can be accomplished in a single year's course. The author suggests the possibility of beginning with the last lessons on

[1] Pratt, H. S. *Invertebrate Zoölogy.* Boston, Ginn & Company, 1902. 210 pp.

the unicellular forms and working upward to the higher animals, but he prefers the arthropods for the introductory work because they are so convenient for teaching the fundamental principles of comparative anatomy.

Apparently there is no special reason for the position of the lesson on the ascidians between those on the mollusks and echinoderms. Probably most teachers will prefer to place this type at the end of the course on invertebrates, when there is a natural transition to the study of the vertebrates.

In the plan of the laboratory directions there is a general resemblance to the well-known guides by Huxley and Martin, and Marshall and Hurst; but there is a great and important difference in that there is not placed before the student a description so complete as to limit the laboratory work to that of merely examining the natural objects in order to verify the printed statements. On the contrary, we find a judicious combination of description of the difficult and time-wasting points with practical directions for suggested problems which are not beyond the student's ability and time for investigation. Such an arrangement gives a desirable mean between two common extreme methods of laboratory teaching, — the one aiming to inform the student through verification of quite complete descriptions, the other attempting to stimulate originality and investigation by leaving him largely dependent upon the natural materials, with a minimum of direction. A combination of the two methods in a laboratory manual will be welcomed by all teachers who believe that the aim of zoölogical instruction is not only to furnish students information concerning the science, but also to give them practice in acquiring some knowledge through their own investigations.

In addition to the practical directions, the book contains a useful appendix on classification of animals and one with short definitions of the principal groups. An excellent glossary of zoölogical terms serves also to indicate where they occur in the lessons; and there is a general index.

In all essential respects this new laboratory manual appears to be excellent, and it deserves the attention of all teachers who use invertebrate types in their courses of zoölogy. M. A. B.

Notes on Birds. — A very good local list of the birds of northwestern Montana is presented in *The Summer Birds of Flathead Lake*, by P. M. Silloway, issued as a bulletin of the University of Montana. It includes an annotated list of 128 species noted between

June 5 and August 29, and notes on the nests and eggs of about twenty-four common species. There are sixteen excellent plates made from photographs of the nests and eggs. The list will be of particular value to western ornithologists, but it is also of interest to those in the East who care to learn something of the western representatives of some of our eastern forms.

The *Proceedings of the Nebraska Ornithologists' Union at its Second Annual Meeting*, held in Omaha, Jan. 12, 1901, contains not only a very creditable number of interesting papers, but gives evidence of an energy and ability among the leaders of the union that augur well for the future of ornithology in the state. The papers presented cover an unusually wide range; they include an historical account of the formation of the union; a list of the breeding birds of the state; accounts of the nesting of Bell's vireo; accounts of young birds in captivity and in the nest; a description of a peculiar disease of birds' feet, and an account of internal parasites of Nebraska birds; and papers dealing with methods of teaching bird study in schools and of keeping migration records. A short paper on the blue jay falls so far below the level of general excellence as to emphasize the serious tone of the other papers. The paper on Nebraska records gives assurance that the interesting problems of distribution which the position of the state presents will be worked out with care and patience.

The Smithsonian Institution publishes a reprint of Oberholser's "Catalogue of a Collection of Humming Birds from Ecuador and Colombia," from the *Proceedings of the United States National Museum*. The catalogue contains descriptions of one new species and three new subspecies, besides many of the collectors' field notes.

CORRESPONDENCE.

To the Editor of the American Naturalist:

SIR: In his article in the May *Naturalist* on the "Structure and Classification of the Tremataspidæ," Dr. William Patten returns again to the question of the origin of the vertebrates from a supposed arthropod ancestor. It will be remembered that in two earlier papers[1] he compared the sutures and other markings on the head shield of trilobites with those on the dermal armor of Pterichthys and Bothriolepis; and we are confident that paleontologists will dissent as strongly from his latest as they did from his earlier conclusions that ostracoderms and arthropods are genetically related. The view expressed by him about eight years ago, that the three-layered dermal skeleton of ostracoderms is a modification of that in arthropods similar to Limulus, also lacks confirmation from other sources. His present procedure, however, is of the boldest; for on the startling assumption that ostracoderms were animals having *many pairs of jointed appendages*, — on merely a suspicion that this was true, — he finds it necessary to "create for them a new class, one that shall occupy a position between the true vertebrates and arthropods, and unite these two great groups into one compact phylum."

His account of the habits, development, and even some of the morphological characters of these "arthropod-like animals" is of such extremely speculative nature that few can hope to read with him the unwritten records of the past. For if it be not by intuition, how else can one know that ostracoderms originally progressed "through the soft mud on the bottom of shallow water with the usual position of dorsal and ventral sides reversed"; that after leaving the bottom they righted themselves into the true vertebrate position; and that this acrobatic performance was accompanied by a migration of the eyes from the haemal to the neural surface of the body? Or in what antediluvian aquarium, we wonder, was the locomotion of Eurypterus observed to be "by brief, spasmodic excursions"? And what authority have we for supposing that the "hypostomeal eyes of trilobites" (Lindström) were in the slightest

[1] *Quart. Journ. Micr. Sci.*, vol. xxxi (1890), pp. 359–365; *Anat. Anzeiger*, vol. ix (1894), pp. 429–438.

sense visual organs, or, in fact, anything but mere muscular impressions?

But these are trite criticisms in comparison with what might be said respecting Patten's remarkable declaration that ostracoderms possessed many pairs of jointed appendages. To refute this is to nullify the author's sole new claim that these creatures are "genetically related to arthropods, or that, through changes in structure and function, one type has been derived from the other"; for all other of the well-known resemblances may be explained as due to mimicry, or to incidental parallelism dependent on environment.

We have already characterized this assertion of Patten's as a surmise; we will go further, and say that it is not only an unproved hypothesis, but one that is absolutely unsupported by any specimens that have yet been described. If examples of Cephalaspis have been found which display "a fringe of 25 to 30 pairs of jointed and movable appendages along the ventral margin of the trunk," the present reviewer for one will confess that he has never seen nor heard of them. As for "Lindström's important discovery of an appendage in Cyathaspis," this detached and unjointed fragment is probably to be interpreted as a spine or cornu. But Professor Patten does not stop here: he points to a series of marginal openings in the shield of Pteraspis, Cyathaspis, and Tremataspis, commonly regarded as branchial, and declares that they "must" have served for the attachment of appendages. He surmises that in Tremataspis the latter "decreased in size from before backwards, and were possibly too delicate to be well preserved in a fossil condition." Fearful lest our rude touch should annihilate these frail conjectural organs, we will simply refer those interested to Dr. Traquair's comparison of Tremataspis with Birkenia, in which the branchial openings (commonly so-called) are disposed relatively as in the skate and shark.[1] A comparison, also, of the anterior ventral plates of Tremataspis with the very similar ones of Drepanaspis, in our opinion would have been far more instructive than our esteemed friend's attempt to homologize certain of them with the jaws of an arthropod.

The position of the mouth in Tremataspis we shall believe, until the contrary is proved, to have been correctly determined by Rohon, who places it immediately behind the rim of the head-shield, as in other ostracoderms where the oral plates are satisfactorily known. Patten, however, basing his conclusions on the solitary example studied by Rohon, challenges the latter's interpretation, and would

[1] *Trans. Roy. Soc. Edinb.*, vol. xxxix (1899), pt. iii, p. 859.

have us suppose that one of the plates of the ventral armor functioned as oral. The author's employment of such generic and family misappellations as "Tolypaspis" and "Pterichthydæ" respectively, is contrary to all recognized principles of nomenclature.

That part of Professor Patten's article which embodies a redescription of the dorsal and ventral shields of Tremataspis, based on four or five unusually perfect specimens from the Isle of Oesel, possesses great merit, and paleontologists should be truly grateful to him for having increased our knowledge of this primitive chordate in several important respects. The more extensive memoir on the same subject which is promised will be awaited with great interest; and further enlightenment with regard to the gill openings and position of the mouth in ostracoderms will be particularly welcome.

C. R. Eastman.

Cambridge, Mass.

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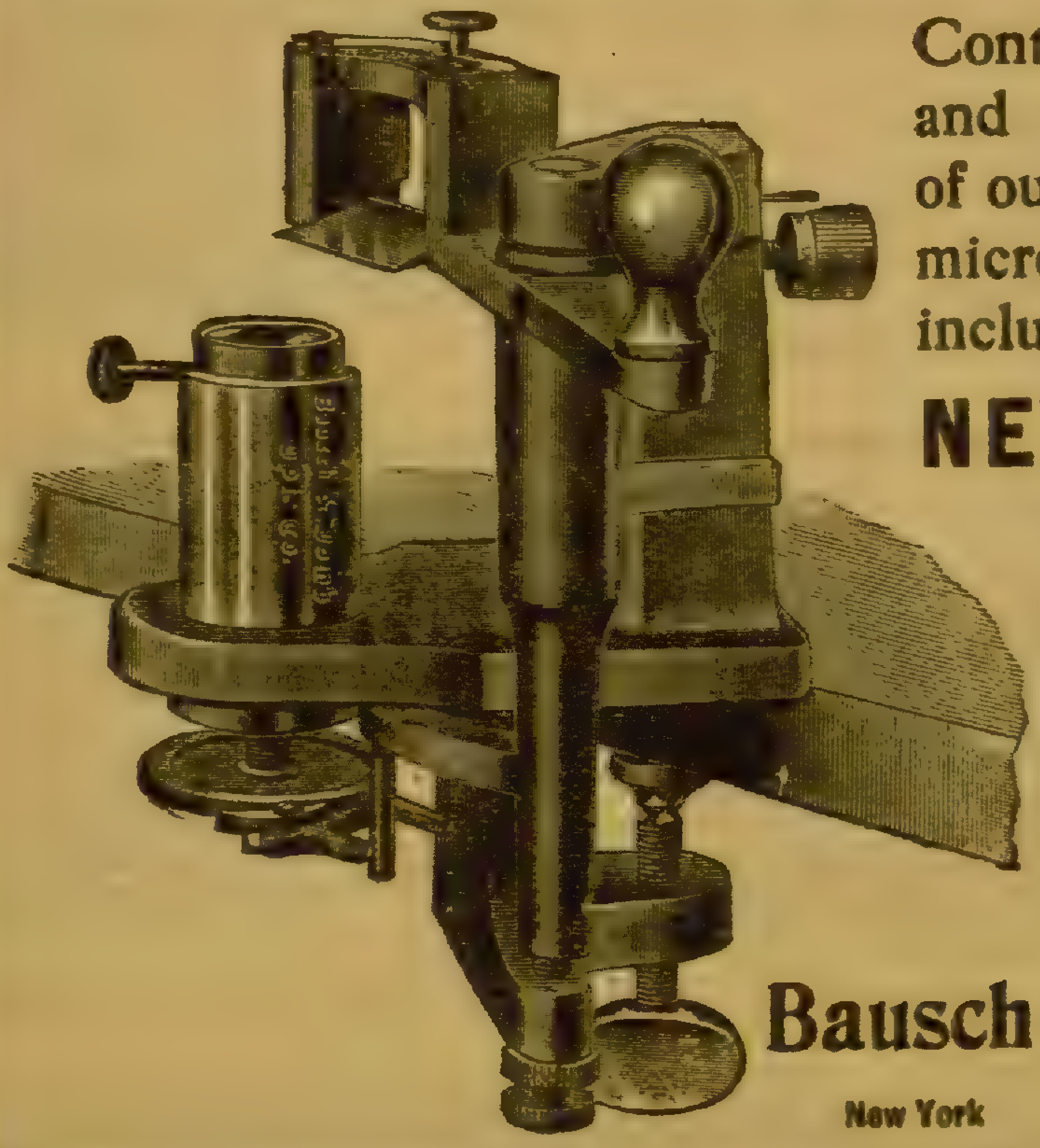

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CONTRIBUTIONS FROM THE ZOÖLOGICAL LABORATORY OF THE MUSEUM OF COMPARATIVE ZOÖLOGY AT HARVARD COLLEGE. E. L. MARK, Director. No. 134.

A CASE OF ABNORMALITY IN CATS' PAWS.

FREELAND HOWE, Jr.

This paper contains an account of facts learned by the study of the walking pads, the muscular, vascular, nervous, and skeletal systems of the manus of a polydactyle and syndactyle cat. The cat furnishing the material for this study was one of a strain of polydactyle cats living in Cambridge, Massachusetts, and descended from a polydactyle cat which lived at the astronomical observatory of Harvard University. All four legs of the cat dissected were preserved in alcohol and were kindly given me for study by Dr. C. B. Davenport, under whose direction the work was done. To him and to Prof. E. L. Mark I wish to extend my thanks for kind advice and criticism.

Each fore paw had six toes; the toes of the hind paws were fused in pairs almost to the ends of the claws, as is shown in Figs. 1 and 2.

The syndactyle hind paws have not been dissected, but a drawing of the palmar and dorsal surfaces is shown in Figs. 1 and 2 respectively. Walking pads and distal phalanges both indicate that the four digits are fused in pairs.

I wished to determine, if possible, which toe of each fore paw is the extra one, and what is the nature of the evidence.

I have been unable to learn of any account of a study on material precisely similar to this. The collection of facts in Bateson's "Materials for the Study of Variation" covers the ground worked over by previous authors, and this, with Poulton's papers, includes an account of all the published facts on the subject, as far as known to me. Previous study has been only on the walking pads and on the skeleton. Bateson described principally skeletal structures, and Poulton studied the walking pads. They have drawn their conclusions as to the true nature of polydactylism from facts learned from these two organs only. It is, of course, desirable to have as complete a knowledge as possible of the anatomy of the paw, as a basis for any conclusions to be drawn. I find from my dissections that the evidence furnished by the walking pads and skeletal system is borne out by the other organs mentioned.

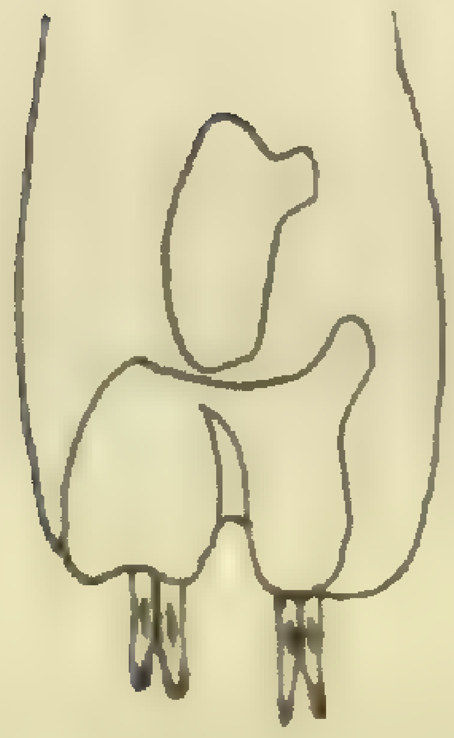

FIG. 1.

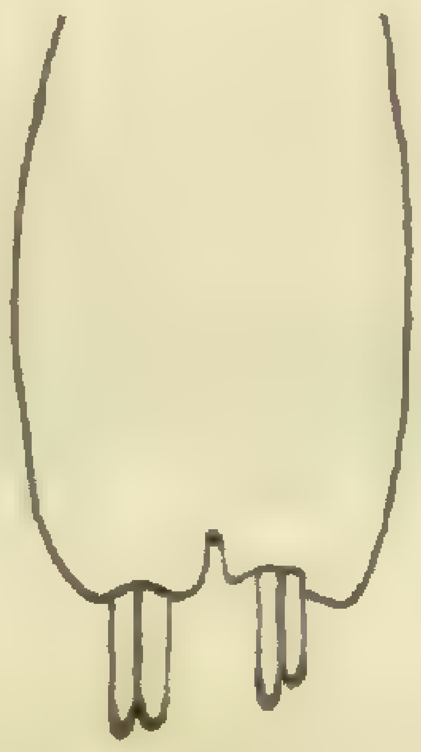

FIG. 2.

FIG. 1. — Palmar aspect of hind paw of abnormal cat, showing fused pads.

FIG. 2. — Dorsal aspect of hind paw of abnormal cat, showing claws fused in pairs.

The general appearance of the polydactyle paw studied, apart from the increased number of digits, is quite different from that of a normal fore paw. The radial digit in the polydactyle paw extended much nearer to the end of the paw than the pollex normally does, the digits being more nearly of the same length than in the normal paw. A comparison of the relative positions of the ungual and middle phalanges during the retraction of the former will be made when we come to the study of the bones.

The walking pads of the polydactyle paw (Fig. 4) differ from those of the normal paw (Fig. 3) in that the phalango-metacarpal

pad (*pulv.phlx-mt'carp.*) of the polydactyle is five-lobed instead of three-lobed as normally, and the lobes in the polydactyle paw are more clearly marked off from one another than in the normal paw. The parts of the five-lobed pad which appear to correspond to the phalango-metacarpal pad of the normal paw are the three external lobes which are more closely associated with one another than with the two internal lobes; while the two internal lobes are more closely applied to each other than to the three external ones. That

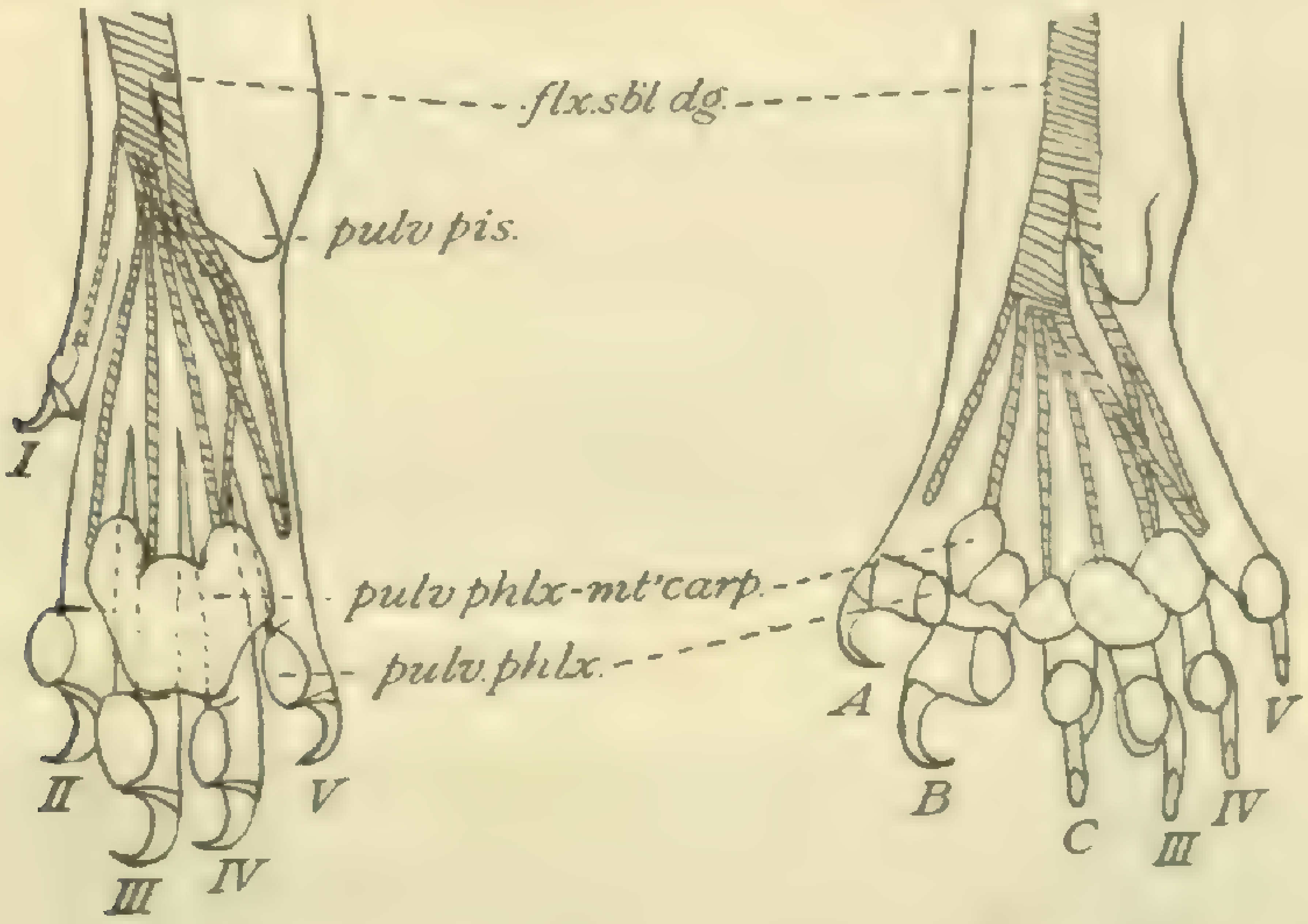

Fig. 3. Fig. 4.

Fig. 3. — Palmar aspect of right fore paw of normal cat.

Fig. 4. — Palmar aspect of right fore paw of polydactyle cat. *A*, radial digit; *B*, second digit, etc.; *I*, pollex; *II*, index; *III*, medius; *IV*, annulus; *V*, minimus; *flx.sb'l.dg.*, flexor sublimis digitorum; *pulv.phlx.*, phalangal pads; *pulv.phlx.-mt'carp.*, phalango-metacarpal pad; *pulv.pis.*, pisiform pad.

five lobes instead of three existed in the polydactyle paw is probably due to the fact that one lobe was added by the formation of an extra digit, and that the growth of the radial digit, which occurred to so unusual an extent that it functioned more like a walking digit than the pollex normally does, excited the growth of a phalango-metacarpal pad on this digit also. In both the normal and the polydactyle paw there is a walking pad on the distal end of each middle phalanx (*pulv.phlx.*) and on the pisiform bone (*pulv.pis.*).

MUSCLES.

As in the normal fore paw, the muscles *extensor carpi radialis longior* and *extensor carpi radialis brevior* (Figs. 5, 6, *ext.carp.r.lg.* and *ext.carp.r.brv.*) are inserted on the proximal dorsal surface of the second and third (counting from the radial side) metacarpal bones respectively.

Considering the evidence of these two muscles alone, we should infer that in the polydactyle paw the radial side is normally formed and that the extra digit is external to (on the

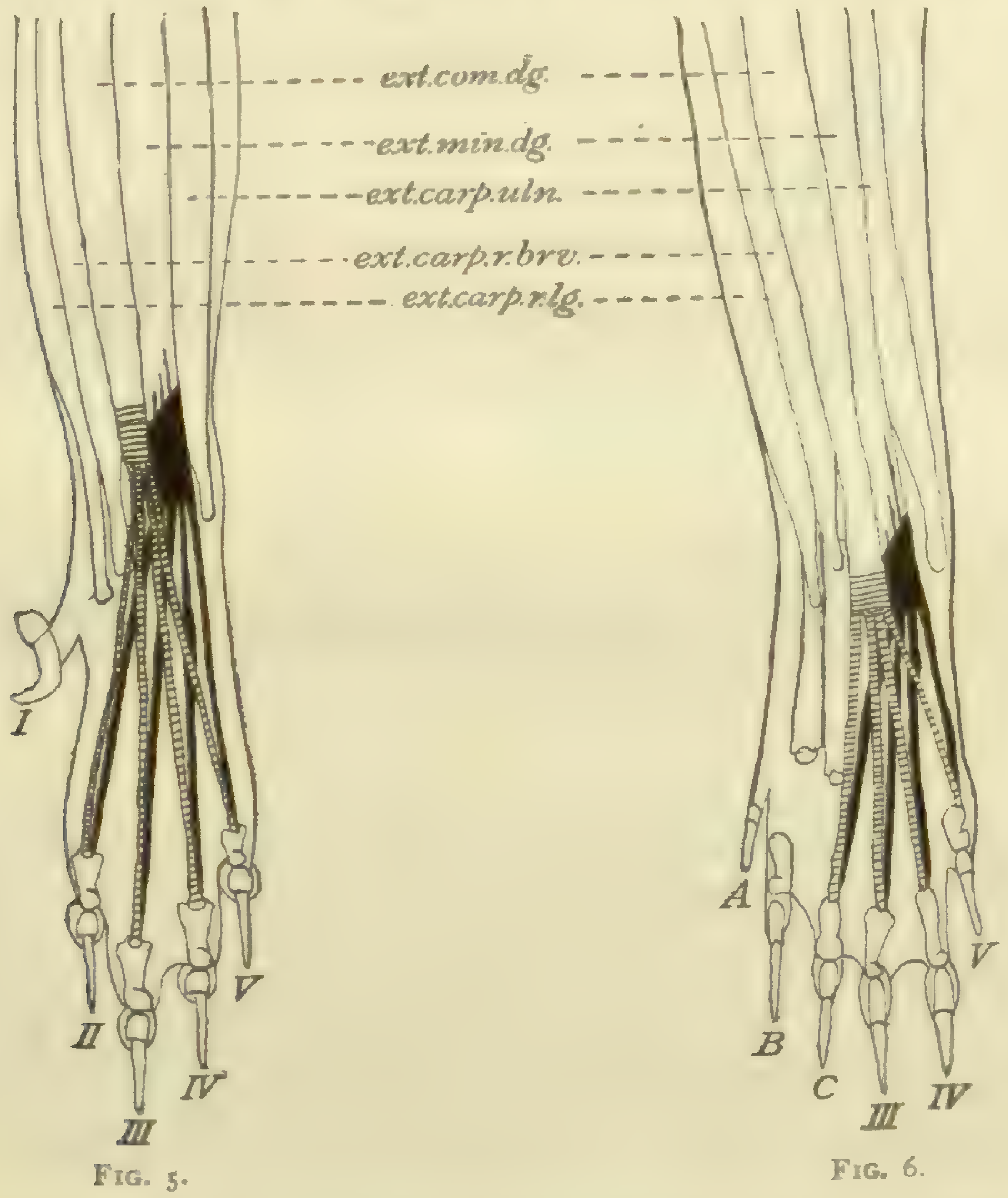

FIG. 5. FIG. 6.

FIG. 5.—Dorsal aspect of left manus of normal cat, showing dissection of muscles. *ext.carp.r.brv.*, extensor carpi radialis brevior; *ext.carp.r.lg.*, extensor carpi radialis longior; *ext.carp.uln.*, extensor carpi ulnaris; *ext.com.dg.*, extensor communis digitorum; *ext.min.dg.*, extensor minimi digiti.

FIG. 6.—Dorsal aspect of left manus of polydactyle cat, showing dissections of same muscles as in Fig. 5.

ulnar side of) the third one, for in the polydactyle paw there are three digits external to the insertion of the *extensor carpi radialis brevior*, whereas in the normal paw there are only

two. Such an inference, however, is not borne out by the evidence of other muscles and tissues.

Muscles *extensor communis digitorum* and *extensor minimi digiti* (Figs. 5, 6, *ext.com.dg.* and *ext.min.dg.*) in both normal

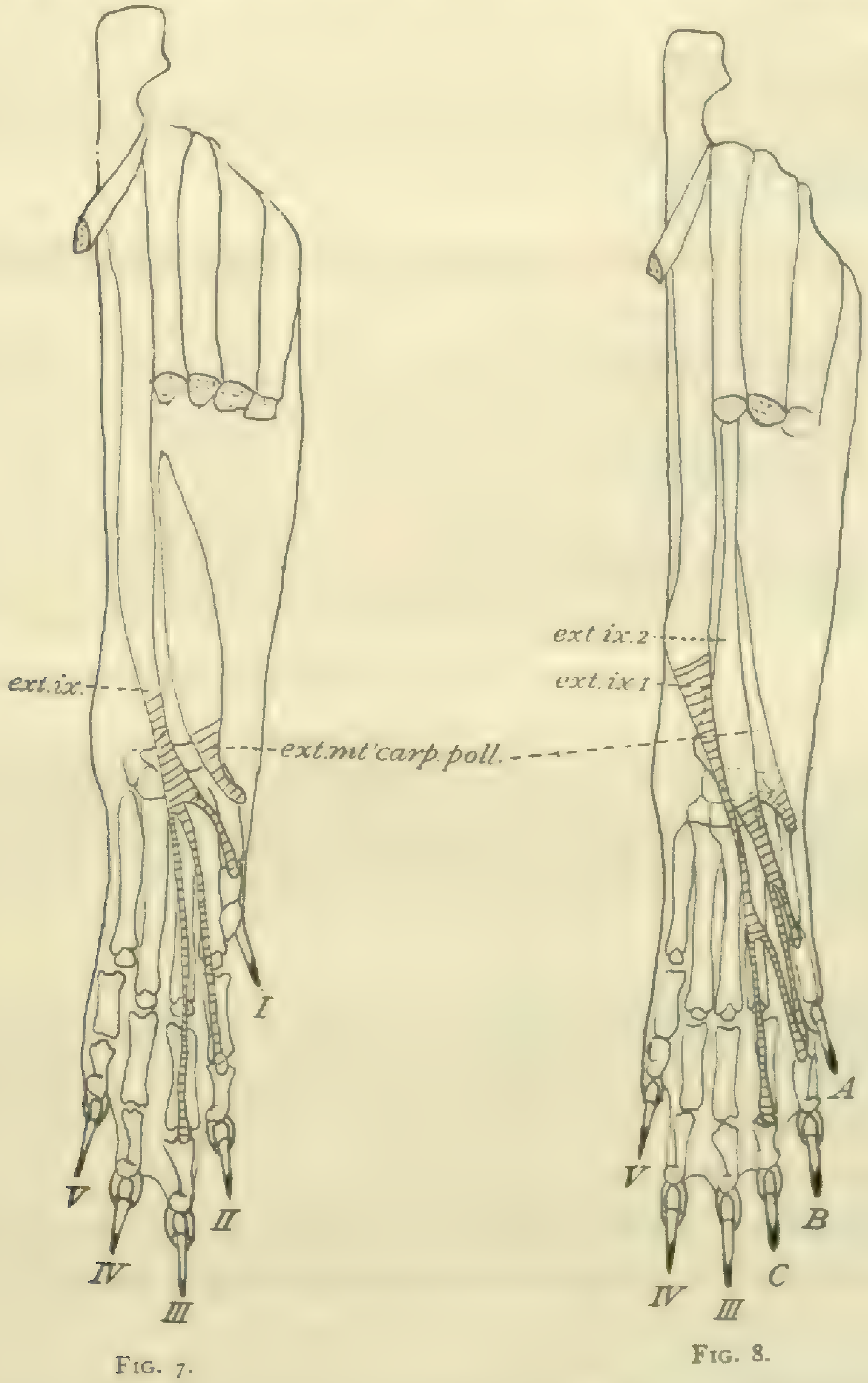

Fig. 7.

Fig. 8.

Fig. 7. — Dorsal aspect of right manus of normal cat, showing dissection of deep muscles. *ext.ix.*, extensor indicis; *ext.mt'carp. poll.*, extensor metacarpi pollicis.

Fig. 8. — Dorsal aspect of right manus of polydactyle cat, showing same deep muscles as in Fig. 7. (See text for description of *ext.ix.1* and *ext.ix.2*.)

and polydactyle paw extend to the proximal dorsal surface of the middle phalanx of each of the four external digits. The distribution of these muscles points to the inference that the

four external digits of the polydactyle paw correspond to the external four in the normal cat, and that the extra digit occurs on the radial side of the four external digits, an inference which, with some modifications, seems to be confirmed by other facts.

Muscle *extensor carpi ulnaris* (Figs. 5, 6, *ext.carp.uln.*) in both normal and polydactyle paw is inserted on the ulnar metacarpal.

The *indicator* (Fig. 7, *ext.ix.*) is somewhat variable in respect to its insertion, even in normal specimens, sometimes supplying the pollex, index, and medius, sometimes only the pollex and index. In the polydactyle paw a peculiar arrangement exists, in that there are two muscles in place of one. That which, from relative position and insertion, seems to correspond to the normal one (Fig. 8, *ext.ix.1*) is distributed to the second (*B*) and third (*C*) digits.

In addition to this muscle there is under it, and distinct from it, another muscle (*ext.ix.2*), which passes in the same general direction to the two internal digits (*A* and *B*, Fig. 8). This muscle has a more distal origin than does the one supplying digits *B* and *C*; it originates from the dorsal border of the ulna and passes directly over the muscle *extensor metacarpi pollicis* (*ext.mt'carp.poll.*). Comparisons of the two indicators with each other and with the normal muscle seem to point to a readjustment to meet a new condition of the manus.

In both the normal and the polydactyle manus the radial metacarpal furnishes insertion for the *extensor metacarpi pollicis* (Figs. 7, 8, *ext.mt'carp.poll.*).

Muscle *flexor carpi radialis* in both the normal and the polydactyle paw has its tendons inserted on the proximal ends of the palmar surface of the second (counting from the radial side) metacarpal.

The ulnar part of the *flexor sublimis digitorum* in both normal and polydactyle paws has tendons extending to the first and second digits, counting from the *ulnar* side (Figs. 3, 4, *flx.sb'l.dg.*), while the tendons from the radial part of the muscle extend in the normal paw to the four, and in the polydactyle paw to the five, digits nearest to the radial side.

The fact that in the polydactyle paw the union between the tendons to the digits marked *IV* and *V* (Fig. 4) extends further distally than in the normal paw (Fig. 3) is apparently less important than the fact that in the polydactyle paw the radial part of the muscle has five tendons while the normal paw has only four.

Muscle *flexor profundus digitorum* (Figs. 9, 10, *flx.profnd.dg.*) has in the normal paw five, and in the hexadactyle paw six,

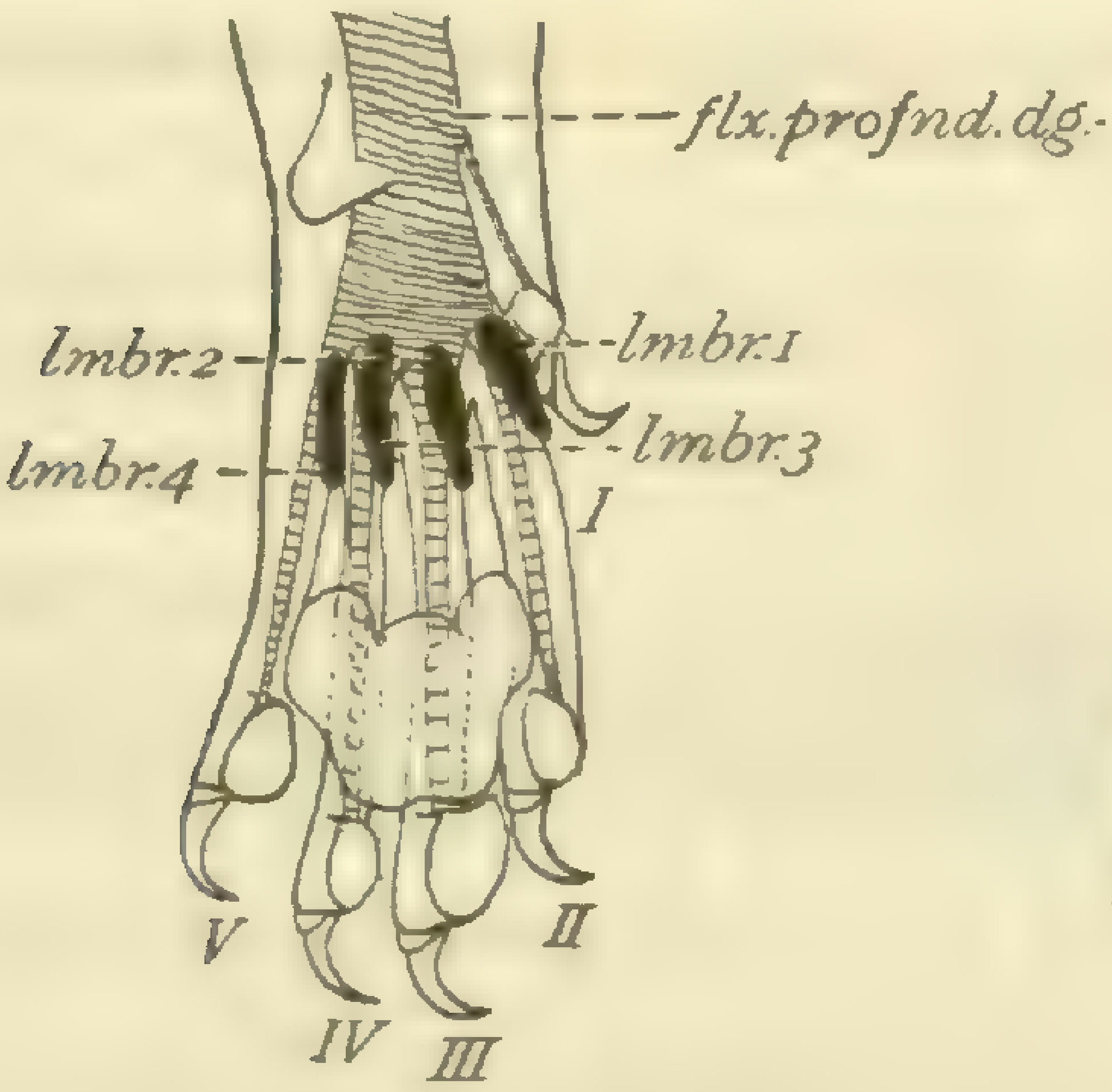

Fig. 9.

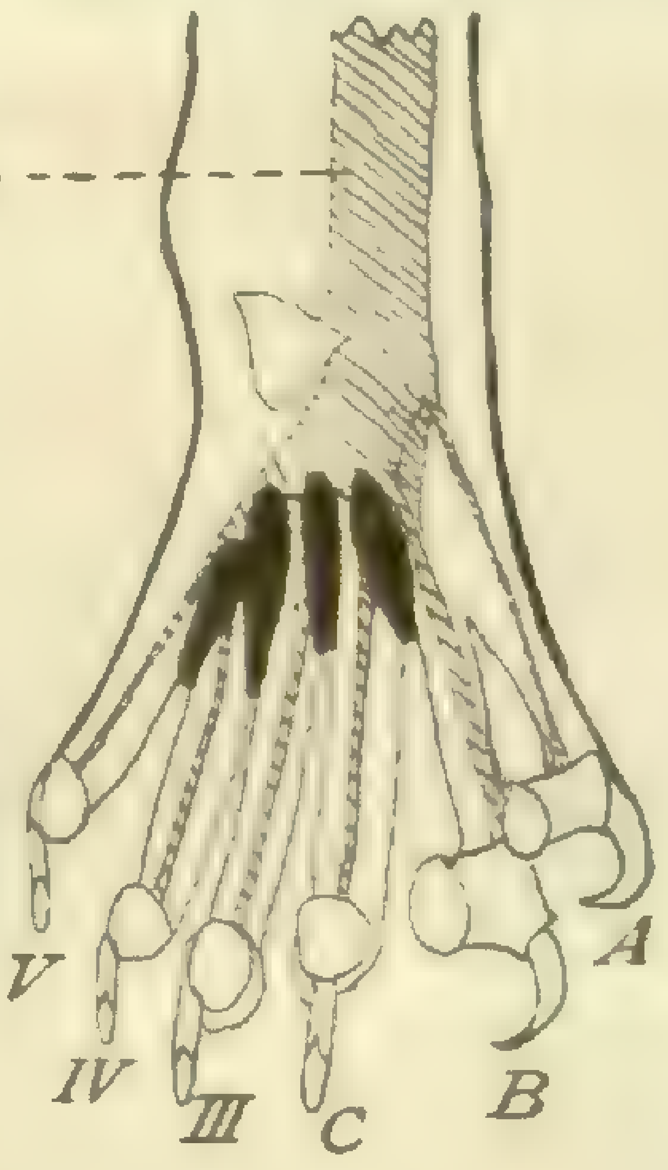

Fig. 10.

Fig. 9. — Palmar aspect of left manus of normal cat, showing dissection of deep muscles.

Fig. 10. — Palmar aspect of left manus of polydactyle cat, showing muscles as in Fig. 9. *A*, radial digit of polydactyle manus; *I*, that of normal manus; *flx.profnd.dg.*, flexor profundus digitorum; *lmbr.1–4*, lumbricales 1–4.

tendons distributed one to each digit. There is no evidence here as to which digit is the extra one.

Muscle *flexor carpi ulnaris* is inserted on the pisiform bone in both normal and polydactyle paws.

There are four *lumbricales* in both normal and polydactyle paws (Figs. 9, 10, *lmbr. 1–4*). In both cases these are inserted one each on the radial side of the proximal phalanx of each of the four external digits. In the polydactyle paw there is no lumbrical superficial to the radial border of the distal part of the *flexor profundus digitorum*.

Blood Vessels.

The arrangement of the veins on the dorsal surface of the normal and the polydactyle fore paw is shown in Figs. 11 and 12. The only points that can be taken as homologous for determining the corresponding veins in the normal and polydactyle paw are the most distal point of the loop formed by the anastomosis of the ulnar (*v.uln.*) with the radial (*v.r.*) vein. This point in both normal and polydactyle paws seems to be between digits marked *III* and *IV*. Starting from this point, we see that in the normal paw there are three branches, and in the polydactyle paw four branches, which contribute to the radial vein. These facts suggest the conclusion that the extra digit of the polydactyle paw is on the radial side; but owing to the uncertainty of the exact position of this point of reference, the evidence from the veins is of less value than that from some of the other organs.

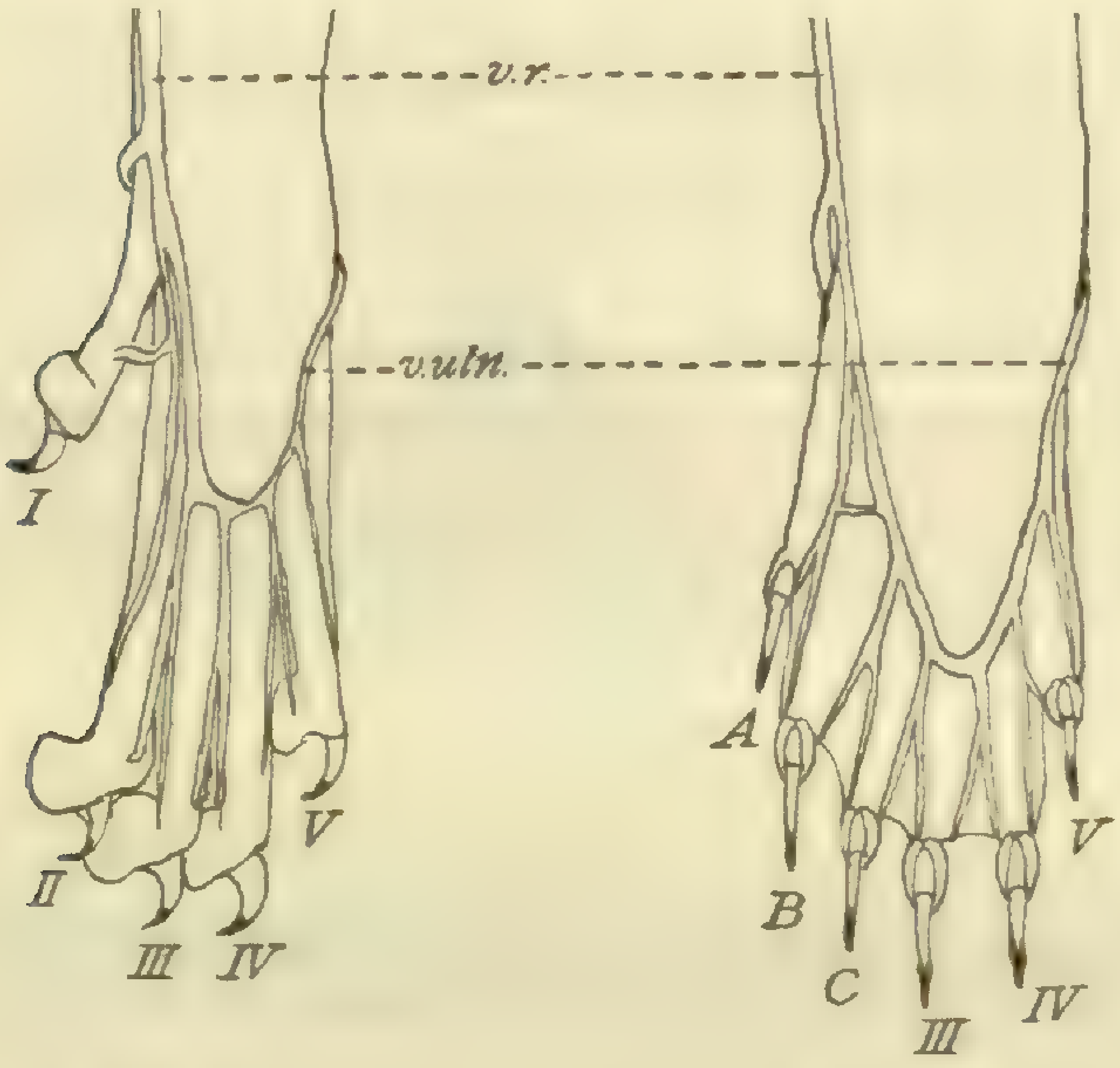

Fig. 11. Fig. 12.

Fig. 11. — Dorsal aspect of left manus of normal cat, showing arrangement of veins. *v.uln.*, ulnar vein; *v.r.*, radial vein.

Fig. 12. — Dorsal aspect of left manus of polydactyle cat, showing arrangement of veins.

In studying the arteries the only fact which throws any light on the problem is the relative size of the digital branches from the *palmar arch* (Figs. 13, 14). The branch which supplies the radial digit is small in both the normal and the polydactyle paw. In the normal paw the branch to the index is as large as the branches to each of the other three digits; but in the polydactyle paw the branches to digits $A + B$ and $B + C$ (Fig. 14), while about equal to each other in size, are much smaller than those to the external digits.

Nerves.

The *radial nerve* after becoming subcutaneous follows the course and distribution of the dorsal veins, which are shown in Figs. 11 and 12. The *median nerve* (Figs. 15, 16, *n.m.*) besides supplying the muscle *flexor communis digitorum* is distributed to *four* consecutive digits, beginning with the radial side, in the normal and to *five* consecutive digits in the polydactyle paw. In the normal manus the *ulnar nerve* divides, just below the olecranon, into an inner (ventral, *n.uln.v.*) and an outer (dorsal, *n.uln.d.*) branch (Fig. 15). The outer (dorsal) branch passes to the outer side of digit *V* and also sends dorsally a branch to the internal side of the same digit and to the external side of digit *IV*. In both normal and polydactyle manus the internal (ventral) branch of the ulnar (Figs. 15, 16, *n.uln.v.*) supplies the three external digits.

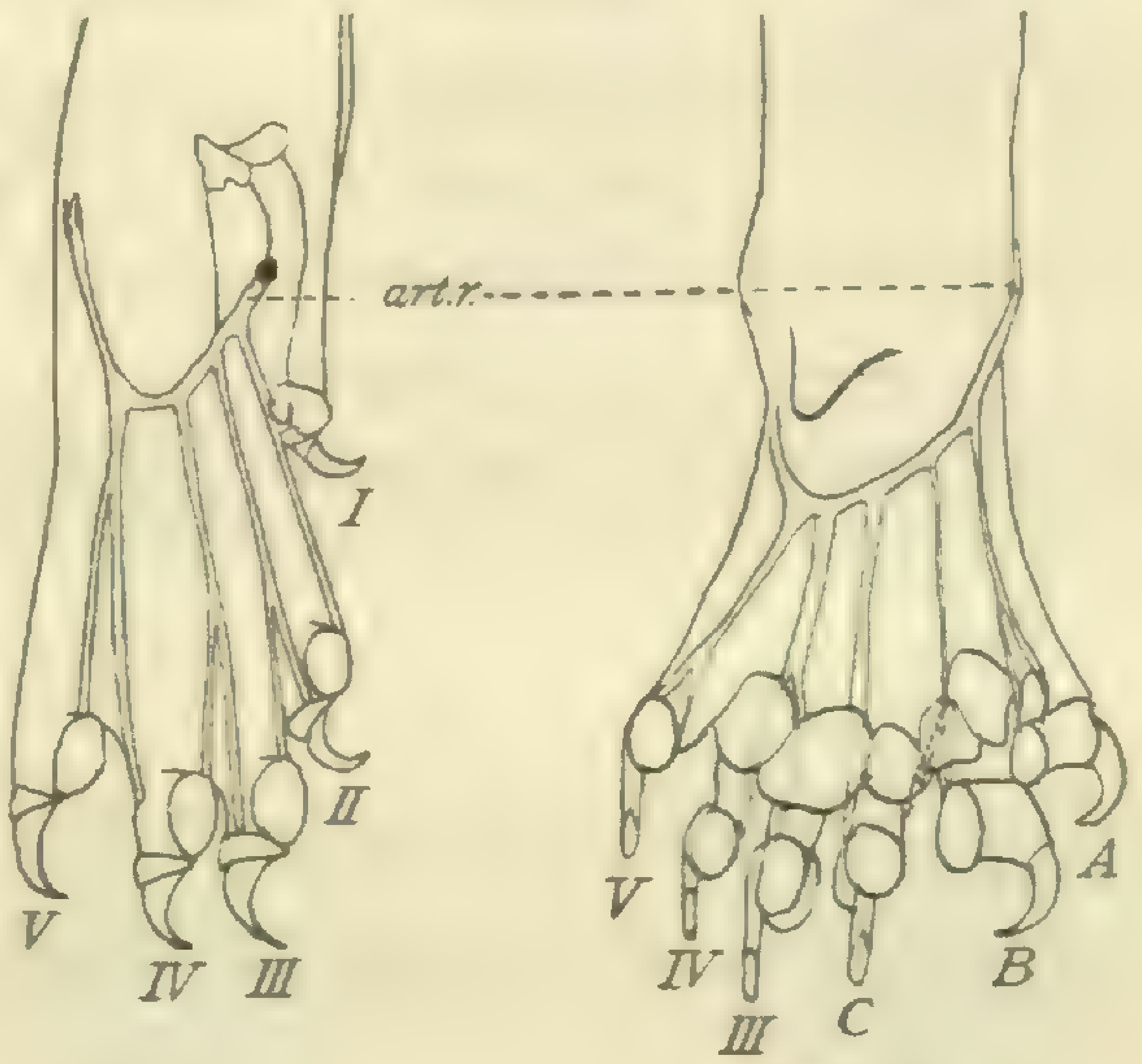

Fig. 13. Fig. 14.

Fig. 13. — Palmar aspect of left manus of normal cat. *art.r.*, radial artery.

Fig. 14. — Palmar aspect of left manus of polydactyle cat.

For a point of reference in comparing the nerves we may take a small branch which passes from the *ulnar* to the *median* nerve. This unites with that branch of the median which in the normal manus (Fig. 15) passes to the ulnar side of digit *III* and to the radial side of digit *IV*. *In the hexadactyle manus (Fig. 16) the branch of the median nerve which is joined by the ulnar nerve likewise passes to the ulnar side of digit III and to the radial side of digit IV.* There is, then, in the abnormal manus radially to the nerve of reference one more digit than exists in the normal manus. This makes it apparent that the modification producing polydactylism has occurred on the radial side of the manus.

Skeleton.

The ulnar, radial, and carpal bones are practically the same in number, relative size, shape, proportion, etc., in the normal and abnormal manus. There are in the polydactyle paw six *metacarpals*, a pollex of two phalanges, and five digits, each with three phalanges. All the bones of the normal paw (Fig. 17) are larger and stouter than those of the polydactyle paw (Fig. 18). Bones of a normal paw were prepared for the purpose of making comparisons with the abnormal skeleton in respect to weight, relative proportions, etc. In making these comparisons, allowances are made for the general differences mentioned above.

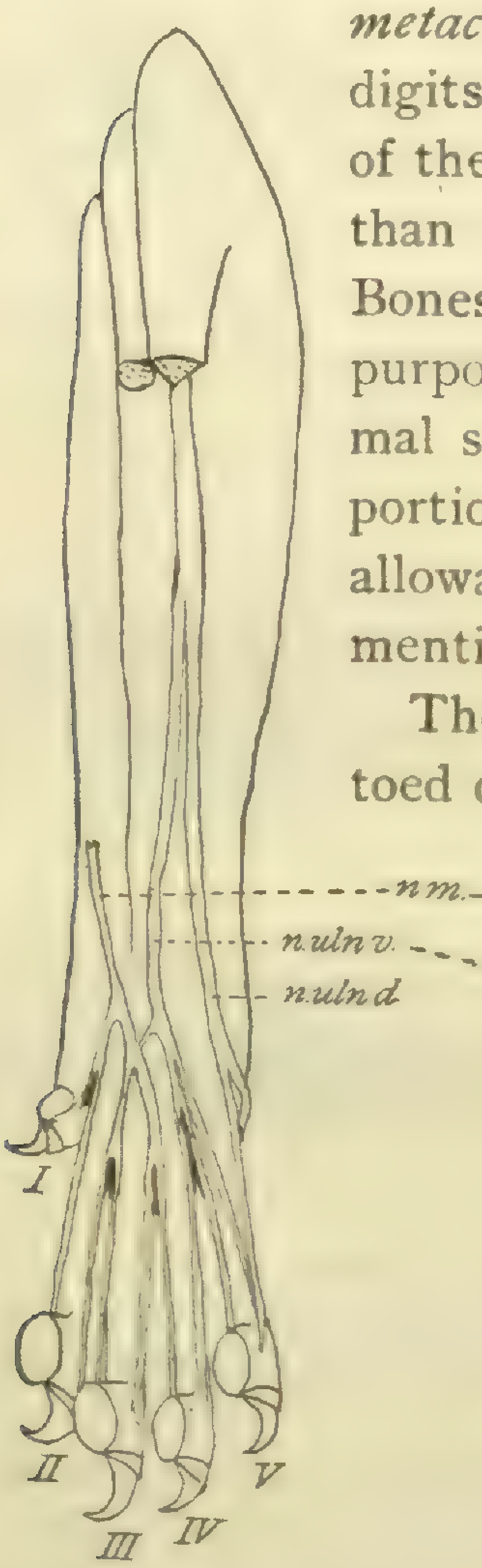

Fig. 15.

Fig. 16.

Fig. 15. — Palmar aspect of right manus of normal cat. *n.m.*, median nerve; *n.uln.d.*, dorsal branch of ulnar nerve; *n.uln.v.*, ventral branch of ulnar nerve.

Fig. 16. — Palmar aspect of right manus of polydactyle cat.

The *radial sesamoid* of the *carpus* of the six-toed cat (*ses.*, Fig. 18) is fused to the radial side of the scapho-lunar (*scph-lun.*) and furnishes the place of articulation for the metacarpal of the pollex. In the polydactyle manus the four external metacarpals (*mt'carp.*) have the same articulations with the distal row of carpals as in the normal manus. In the normal manus the *pollex* articulates with the *trapezium* (*trz.*), while in the abnormal manus (Fig. 18) the metacarpal of digit *B* articulates with the trapezium. Metacarpal of digit *A* (Fig. 18) articulates, as previously stated, with the radial sesamoid (*ses.*), which is fused to the scapho-lunar (*scph-lun.*).

The metacarpal bones in both manus are similar, except that there is in the abnormal manus no "groove" for the radial

artery. The metacarpals, as well as the other bones of the pollices, vary considerably in length and thickness, and in this respect will be considered more closely later.

There is no particularly noticeable variation in the proximal series of phalanges (*phlx.prx.*). These bones have the least distinctive characters, differing from one another chiefly in size.

The series of middle phalanges (*phlx. m.*) furnishes very interesting conditions. In both the normal and abnormal manus the three external (ulnar) middle phalanges are carved away on the ulnar side to allow for the retraction of the corresponding ungual phalanges (*phlx.ung.*). The middle phalanx of the index of the normal manus is likewise carved away on the ulnar side, but in the abnormal manus the digit (*C*, Fig. 18) next to the three ulnar digits is carved away on neither side and is therefore "indifferent." The middle phalanx of digit *B* (Fig. 18) has no counterpart in the normal

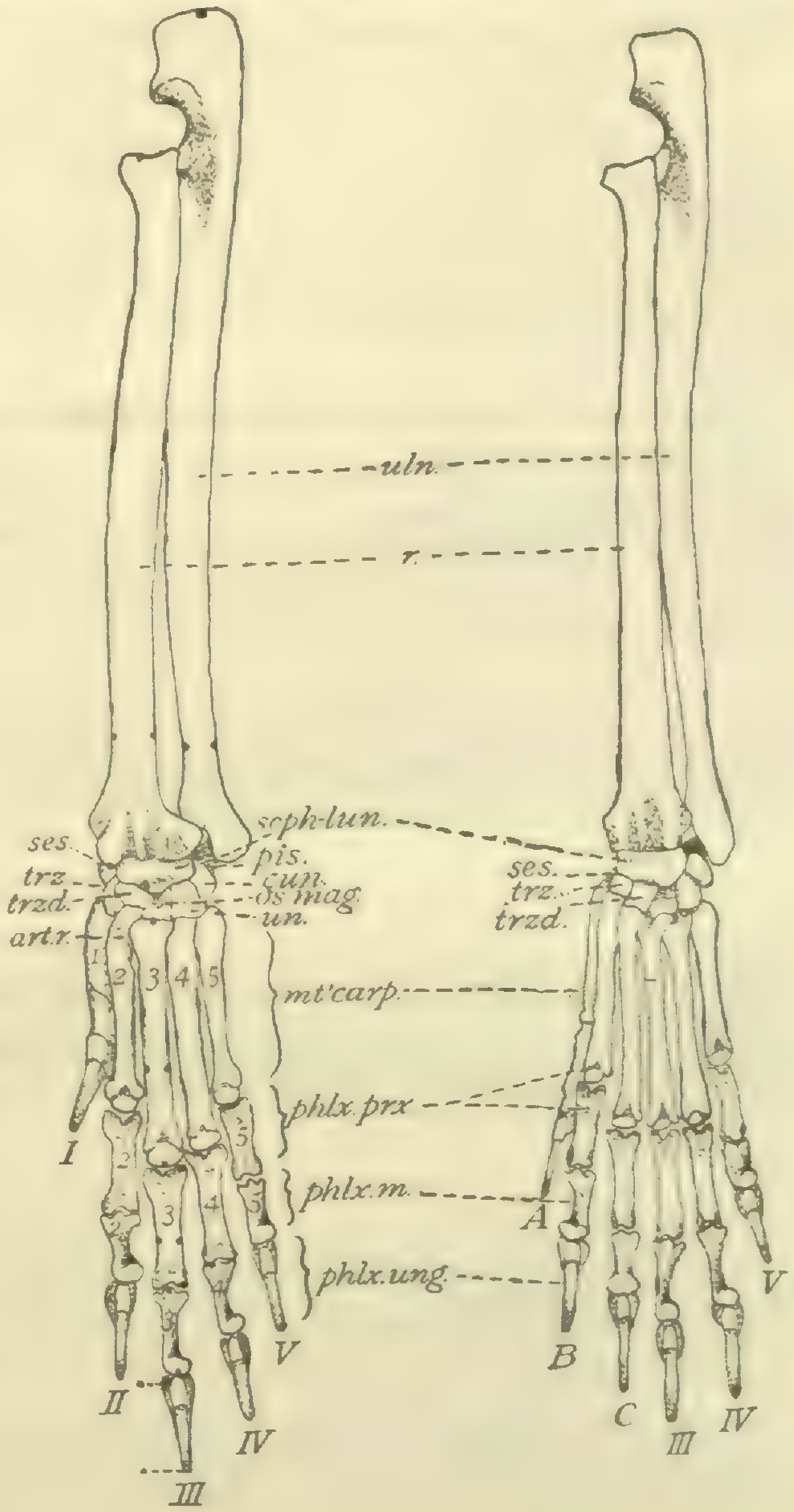

Fig. 17. Fig. 18.

Fig. 17. — Dorsal aspect of skeleton of left manus of normal cat.

Fig. 18. — Dorsal aspect of left manus of hexadactyle cat. *A*, radial digit of abnormal manus: *I*, that of normal manus; *art.r.*, groove for radial artery; *cun.*, cuneiform; *mt'carp.*, metacarpals; *un.*, uncinate; *os mag.*, os magnum; *phlx.m.*, middle phalanges; *phlx.prx.*, proximal phalanges; *phlx.ung.*, ungual phalanges; *pis.*, pisiform; *r.*, radius; *scph-lun.*, scapho-lunar; *ses.*, sesamoid; *trz.*, trapezium; *trzd.*, trapezoid; *uln.*, ulna.

manus, except that it is somewhat like a pollex, which, when retractable, as occasionally happens, is carved away on the radial side.

The ungual phalanges are too nearly alike in the normal and the polydactyle paw to be of service as far as our purpose is concerned.

General Considerations.

The facts learned from the dissection of the polydactyle manus are in part contradictory; that is, some facts suggest that the extra digit occurs on the radial side of the paw, whereas others indicate an extra digit on the ulnar side; but, on the whole, the balance of the evidence points to the existence of the extra digit on the radial side of the three ulnar digits. The evidence which the bones furnish seems to be the most satisfactory, and is borne out in the majority of cases by the other tissues. The middle phalanges of digits *III*, *IV*, and *V* (Figs. 17, 18) are carved away on the ulnar side, as normally. The middle phalanx of digit *C* (Fig. 18) is an indifferent digit, *i.e.*, carved away on neither side. In this it more resembles a pollex than a digit. The middle phalanx of digit *B* (Fig. 18) is carved away on the radial side, in this respect resembling a pollex more than a digit. Digits *III*, *IV*, and *V* in both manus are distinctly similar. Regarding the articulation of the metacarpals with the carpals, it is seen that the five external digits of the abnormal manus have the same articulation as do the five digits of the normal manus. The pollex of the abnormal manus has the articulation abnormal, in that it is with the radial sesamoid, which in this case is fused with the scapho-lunar. Here the five digits nearest the ulnar side are normal.

Considering the three ulnar digits of the abnormal manus to correspond to normal digits, one is naturally led to inquire what modifications the manus has undergone that there should be three digits instead of two on the radial side of the three ulnar normal ones. Further evidence from the bones is interesting in respect to this query.

A comparison of the indices and the weights of the individual bones of both the normal and abnormal manus is shown in the accompanying table. For the purpose of more accurate comparison of the two sets of bones, I have figured the percentage which each bone bears to the total weight of all the bones of the manus to which it belongs (including ulna and radius). The indices of the bones were obtained by finding the ratio between the minimum thickness and the maximum length of each bone. The actual points of measurement are shown by the dots in Fig. 17, *III*. Inspection of the bones first leads us to see that digit *A* (Fig. 18) is much longer than the normal pollex and presents in the undissected manus more the character of a finger than of a pollex. The bones, however, are distinctly those of a pollex, since there are two phalanges only; but they are longer and more slender. In this respect they resemble a finger. The bones of digit *B* (Fig. 18) are more like a pollex than are those of the digit which normally adjoins the pollex. One can also see that digit *C* (Fig. 18) is more like a pollex than is the digit which is normally fourth from the ulnar side. What further facts are there to bear out the idea that where there are normally two digits, there abnormally occur three, each of which partakes somewhat of the general characters of the others?

It is a fact that where normally two digits are found, namely, a pollex and an index, there are found in this special case three, and that the material which would normally form two digits has so distributed itself that each of the three digits which actually occurs partakes of the nature of the other two. Is the abnormal pollex two-thirds pollex and one-third index; the digit next the pollex, one-half index and one-half pollex; and the digit *C* (Fig. 18) two-thirds index and one-third pollex? There seems to be some relation of this sort.

If we compare the indices and the relative weights of the two manus, we come to a like conclusion (see accompanying table). For example, comparing the percentages of total *weights* in the abnormal manus, metacarpal *A* (Fig. 18) is more like the other metacarpals of its manus than is metacarpal *I* of the normal manus like the other metacarpals of its manus;

NORMAL.

	GRAMS WEIGHT.	PERCENTAGE WEIGHT.	MILLIMETERS MEASUREMENT.	PERCENTAGE INDEX.
Ulna	3.467	.333	45 × 1030	.0437
Radius	2.679	.257	52 × 878	.0592
Carpals	.699	.067	—	—
Metacarpals				
I	.135	.012	32 × 112	.286
II	.423	.040	28 × 284	.0986
III	.525	.054	32 × 321	.0997
IV	.445	.043	30 × 300	.100
V	.348	.033	28 × 247	.113
Totals of metacarpals	1.876	.182	—	—
Proximal phalanges				
I	.096	.0092	32 × 82	.402
II	.157	.0158	32 × 136	.235
III	.188	.0187	33 × 155	.203
IV	.161	.0154	30 × 147	.204
V	.127	.0122	29 × 118	.245
Totals of proximal phalanges	.729	.0713	—	—
Middle phalanges				
I	—	—	—	—
II	.097	.0093	23 × 94	.244
III	.108	.0103	23 × 115	.200
IV	.094	.0090	23 × 108	.213
V	.078	.0075	28 × 82	.341
Totals of middle phalanges	.377	.0361	—	—
Distal phalanges				
I	.150	.0144	34 × 102	.333
II	.116	.0111	30 × 100	.300
III	.125	.0120	28 × 100	.280
IV	.102	.0098	28 × 101	.278
V	.089	.0086	28 × 93	.301
Totals of distal phalanges	.582	.0559	—	—
Total of all bones	11.030	—	—	—

POLYDACTYLE.

	Grams Weight.	Percentage Weight.	Millimeters Measurement.	Percentage Index.
Ulna	2.829	.330	40 × 1015	.0394
Radius	2.188	.255	42 × 850	.0490
Carpals	.529	.061	—	—
Metacarpals				
A	.097	.011	20 × 157	.127
B	.261	.030	27 × 231	.113
C	.295	.034	26 × 260	.100
III	.292	.034	26 × 278	.094
IV	.291	.034	24 × 260	.091
V	.237	.027	25 × 212	.118
Totals of metacarpals	1.473	.170	—	—
Proximal phalanges				
A	.054	.0063	19 × 103	.184
B	.123	.0144	31 × 120	.258
C	.123	.0144	30 × 126	.238
III	.133	.0166	28 × 140	.200
IV	.123	.0144	27 × 132	.204
V	.090	.0105	28 × 101	.277
Totals of proximal phalanges	.646	.0766	—	—
Middle phalanges				
A	—	—	—	—
B	.073	.0085	25 × 85	.294
C	.071	.0083	23 × 83	.277
III	.078	.0091	18 × 101	.178
IV	.073	.0085	20 × 96	.208
V	.057	.0066	27 × 72	.375
Totals of middle phalanges	.352	.0410	—	—
Distal phalanges				
A	.092	.0107	24 × 79	.304
B	.110	.0128	25 × 99	.252
C	.105	.0123	28 × 102	.274
III	.096	.0112	28 × 99	.282
IV	.080	.0093	26 × 94	.276
V	.069	.0080	27 × 89	.315
Totals of distal phalanges	.552	.0643	—	—
Total of all bones	8.569	—	—	—

likewise, the metacarpal of digit *B* is more like metacarpal *A* than the metacarpal of digit *II* of the normal manus is like its pollex. Again, the metacarpal of digit *C* is more like its pollex metacarpal *A* than is the metacarpal of digit *III* of the normal manus like its pollex.

The same fact is also borne out by the comparison of the *indices*, which are mathematical expressions of the forms of the bones and can, therefore, be combine in the same way as the percentage weights.

That the two normal radial digits have given place to three, each of which partakes somewhat of the nature of the others, is shown by a consideration of the tissue systems, and in no way does this explanation meet with a decided contradiction. The evidence of the dorsal veins is negative and not contradictory.

I know of no case of polydactylism similar to the one here described. One which is somewhat similar is described by Windle (*Journ. of Anat.*, Vol. XXVI, 1891, p. 100), who in conclusion says: "The musculature shows that where there is an additional digit on the radial side, it and the digit next to the index both partake of the nature of thumbs and may be looked upon as the first and second digits of a hexadactylous manus."

In the case described in this paper, there is no reversion, and the anatomy of the polydactyle paw, as here worked out, has no bearing on either the "pre-pollex" or the "post-minimus" theories. The abnormality seems to result purely from a readjustment of parts. The only definite statement which can be made in regard to this case is that where normally two digits occur, three have here appeared, and that each of these three partakes more of the nature of the others than one of the two normal digits does of the other.

Zoölogical Laboratory,
Harvard University.

THE GASTRULATION OF THE EGG OF BUFO LENTIGINOSUS.

HELEN DEAN KING.

An examination of the literature dealing with the early development of the amphibian egg shows many conflicting observations and theories regarding the origin of the blastopore and the manner of formation of the mesoderm and notochord. It is evident, therefore, that more forms must be studied and the observations in some cases carefully repeated before any general conclusions regarding the origin of these structures can be drawn for the entire group.

The amphibian eggs that have been most studied are those of Rana, Triton, Axolotl, and Bombinator. The present paper deals with the early development of the egg of *Bufo lentiginosus* from the end of cleavage until the closure of the blastopore. The eggs of this amphibian, although very abundant and easily obtained, have been but little used either for observation or for experiment, owing, doubtless, to their small size and to their relatively deep pigmentation, which makes it very difficult to follow the fate of living cells.

Method.

In preparation for sectioning, eggs were killed in various fluids: picro-acetic, picro-sulphuric, formalin, and corrosive-acetic. By far the best results were obtained with corrosive-acetic (5 per cent acetic). Formalin (3–10 per cent) gives exceedingly good preparations for a study of surface structures, but it cannot be relied on to give histological details, as it usually produces numerous cracks in various parts of the egg. The sections were stained on the slide with the mixture of borax carmine and Lyon's blue, recommended in a previous paper (King, 10). With the use of this stain the

nuclei appear red, the yolk blue, and the cell outlines are brought out with great clearness.

The Formation of the Blastopore.

The egg of *Bufo lentiginosus* probably contains a greater amount of pigment in proportion to its size than that of any other common amphibian. It is, therefore, very difficult to study the movements of individual cells before and during the formation of the blastopore, as has been done to some extent in the eggs of several other species of amphibians, where the pigmentation is less extensive and cell outlines can be readily determined.

In the egg of Bufo the pigmentation extends in all cases some distance below the equator, and I have frequently found eggs in which fully three-fourths of the surface was deeply pigmented before the appearance of the blastopore. Individual eggs, even from the same female, differ greatly in the amount of pigment they contain. As a rule, the pigment line extends farther down on one side of the egg than on the other, as seen in Fig. 1, agreeing in this respect with the frog's egg according to Schultze (24), Morgan and Tsuda (17), and Wilson (27).

Sections through an egg at the close of the blastula stage show a large segmentation cavity in the upper hemisphere. Its dorsal wall is formed, as in the frog, of three or four layers of small angular cells of uniform size. The cells forming the outer surface of the egg are almost completely filled with pigment granules, and a considerable amount of pigment is scattered throughout all the cells of the upper part of the egg. The yolk cells below the segmentation cavity are much larger, more rounded, and stain less intensely than the cells in the upper hemisphere. There is the same gradual increase in the size of the cells from the upper to the lower pole that other investigators have noted in the frog's egg.

The dorsal lip of the blastopore invariably appears some distance below the equator of the egg, but never in the middle of the lower hemisphere, as maintained by Houssay (8) for the axolotl and Jordan (9) for the newt.

If the egg has but the usual amount of pigment, the first evidence of the blastopore, in surface view, is a short, dark, almost straight line at the extreme edge of the black cells (Fig. 1). If the pigmentation is unusually extensive, the blastopore appears in its same relative position with respect to the lower pole of the egg but distinctly within the black cells. Whether there is, as the first step in the formation of the blastopore, a "lining up" of the ectoderm cells, as described by Wilson for the frog, I have not been able to determine.

Sections of an egg at the beginning of gastrulation show that the dorsal lip of the blastopore is formed primarily by a sinking in of several of the surface cells (Fig. 9). The shallow

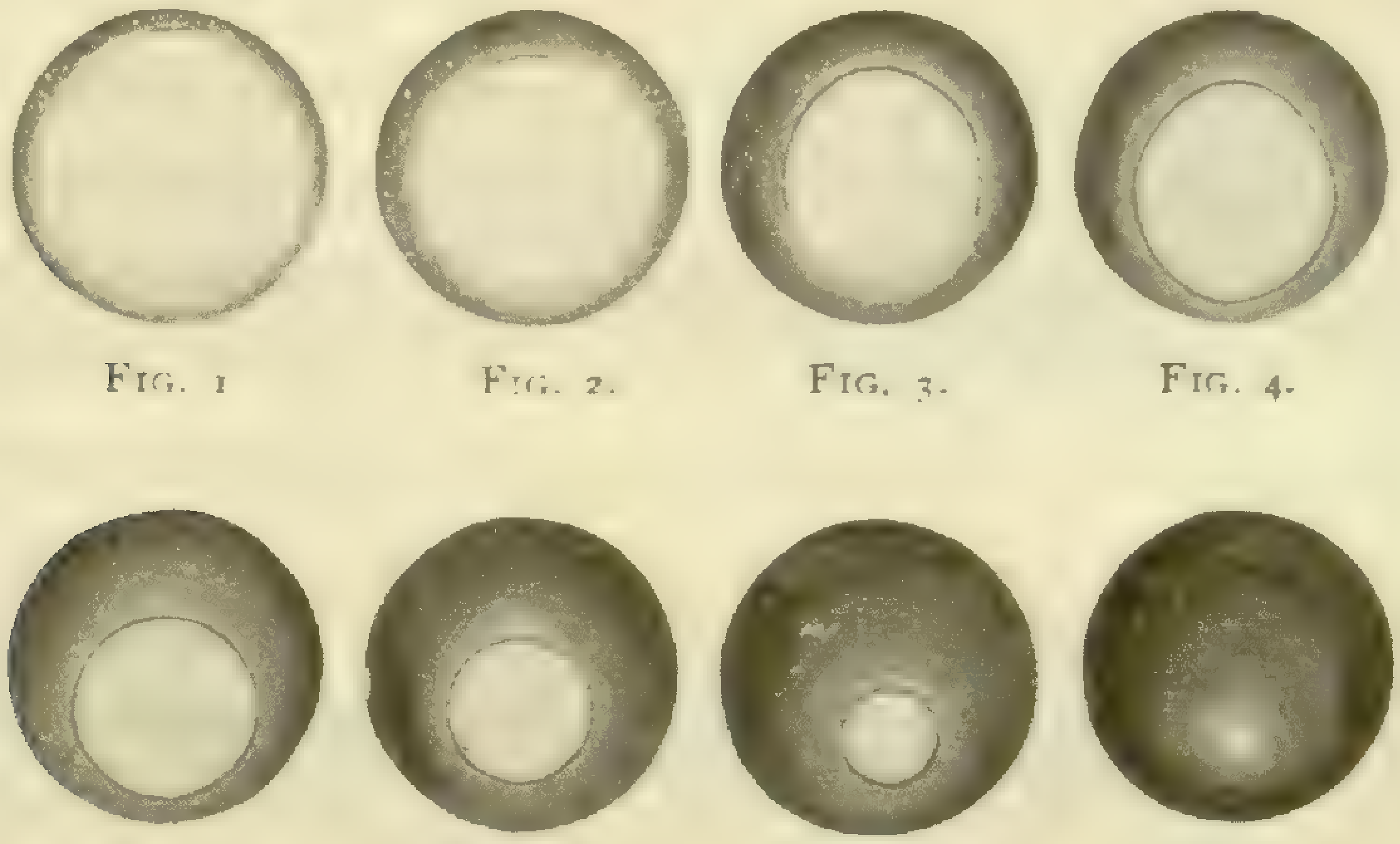

FIG. 1 FIG. 2. FIG. 3. FIG. 4.

FIG. 5. FIG. 6. FIG. 7. FIG. 8.

FIGS. 1-8. — Surface views of the lower hemisphere of an egg during the formation and closure of the blastopore.

depression thus formed is rapidly extended and soon becomes a pronounced furrow (Fig. 10). The cells involved in this sinking in are all, without question, large yolk cells which are decidedly wedge-shaped and contain a considerable amount of pigment in their smaller ends turned towards the exterior (Figs. 9, 10, 11).

After the lateral extension of the dorsal lip to form a crescent, a sagittal section through the blastopore shows that the furrow has deepened considerably and that its inner end is turned up towards the dark pole (Fig. 11). From this time on there is a marked difference in appearance between the cells forming the dorsal wall of the archenteron and those forming the ventral wall. The cells of the dorsal wall are small, angular,

deeply pigmented cells, and they are apparently exactly like the small cells forming the upper surface of the egg, except that they do not contain quite as much pigment. The yolk cells which form the floor of the archenteron are three or four times larger than the cells of the dorsal wall, and they are more rounded and contain little if any pigment. The distinction between these cells is made more evident by the fact that with the combination stain used all the yolk cells appear decidedly blue, while the cells of the dorsal wall of the archenteron and, in fact, all the cells of the upper hemisphere, take a distinctly reddish tint. The cells at the anterior end of the archenteron are still wedge-shaped at this stage. They are intermediate in size between the cells forming the dorsal wall and those forming the ventral wall of the archenteron, and they stain like the yolk cells.

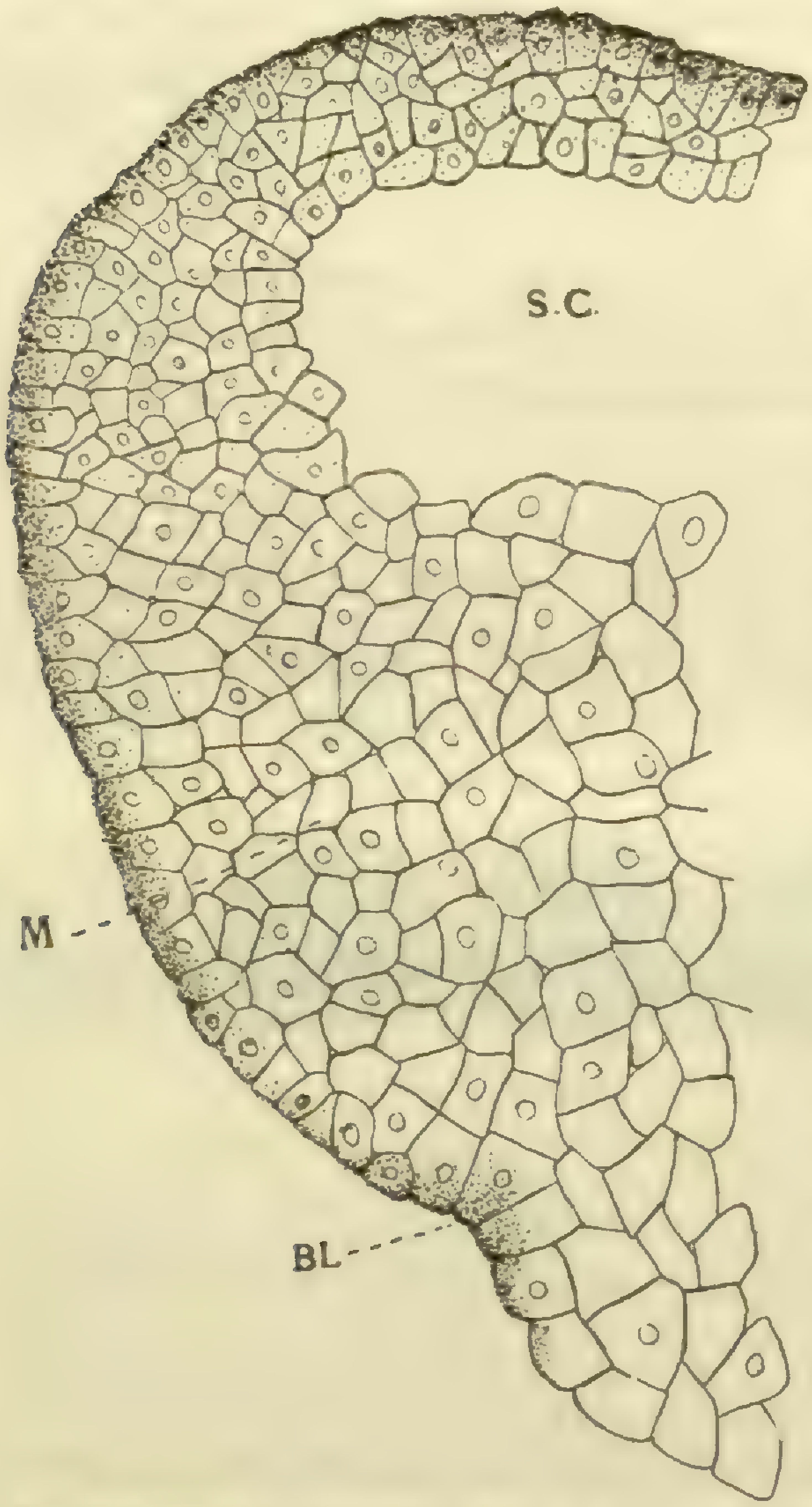

FIG. 9. — Part of a section through the median plane of the blastopore at the stage of Fig. 1, showing the depression of the yolk cells to form the dorsal lip. *S.C.*, segmentation cavity; *BL.*, blastopore; *M.*, cells which are to develop into mesoderm.

In opposition to most investigators, Moquin-Tandon (15), Houssay, Robinson and Assheton (20), and Marshall (14) maintain that the archenteron of the amphibian embryo is not formed by a process of invagination, but by a splitting between yolk cells which thus form the dorsal as well as the ventral wall of the archenteron. In a later paper, Assheton (1)

states that "the formation of the primitive archenteron is by a process of splitting, and is the direct effect of the primary center of growth; whilst the continuation of the cavity produced by an overgrowth is the direct effect of the secondary center of growth."

That the archenteron in the egg of *Bufo lentiginosus* is not formed by a splitting between yolk cells is shown, I think, by a study of a series of well-preserved eggs during the early stages of gastrulation. The archenteron never appears "slit-like" at this time. On the contrary, its walls are usually some distance apart and its inner end is invariably rounded (Figs. 10, 11). Occasionally at the stage of Fig. 12, never earlier, I have seen an irregular cleft between the yolk cells at the anterior end of the archenteron which might, perhaps, be considered a forward extension of the archenteron, but such a cleft is usually seen only in badly preserved eggs where the cells are all more or less separated, and therefore I have always considered that it was artificially produced by the method used in killing and hardening the egg.

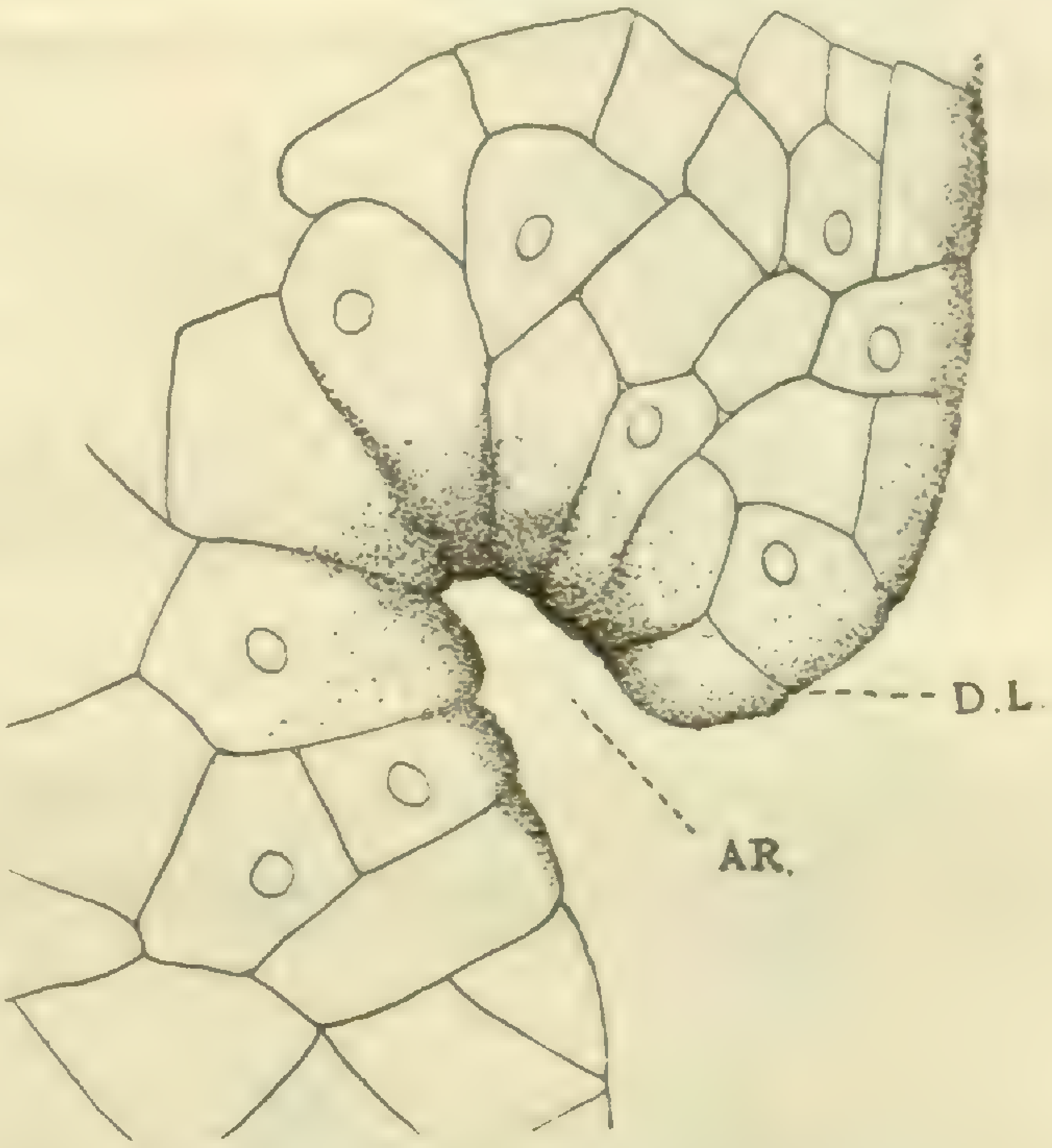

FIG. 10. — Part of a median section through the blastopore at a slightly later stage than Fig. 9, showing the character of the cells at the base of the blastopore furrow. *D.L.*, dorsal lip of the blastopore; *AR.*, beginning of the archenteron.

Jordan, Wilson, and Eycleshymer (4), among others, have watched the disappearance of individual surface cells under the dorsal lip of the blastopore in the early gastrulation stages of the living egg. These observations seem to me to afford conclusive evidence that invagination of cells plays an important rôle in the formation of the archenteron.

The presence of pigment in the inner ends of the cells forming the dorsal wall of the archenteron has been explained by Robinson and Assheton as follows: "The pigmented area is produced and extended by the deposit of pigment in the adjacent margins of a double row of yolk cells which eventually will form the boundary wall of the archenteron, and it also radiates from this area along the adjacent margins of the cells of each row. A slit-like space appears in the middle of the posterior portion of the pigmented area. This space first limits the dorsal lip of the blastopore, and then extends forward and ventrally, following the deposit of pigment, and separating the two rows of marginally pigmented cells from each other." During the early stages of gastrulation there is always found at the anterior end of the archenteron a marked accumulation of pigment that is extended around to include a few of the yolk cells in this region (Figs. 10–12). I have never found more than a few scattered pigment granules in the lower yolk cells except in this particular part of the egg, and, if the archenteron is formed by a splitting

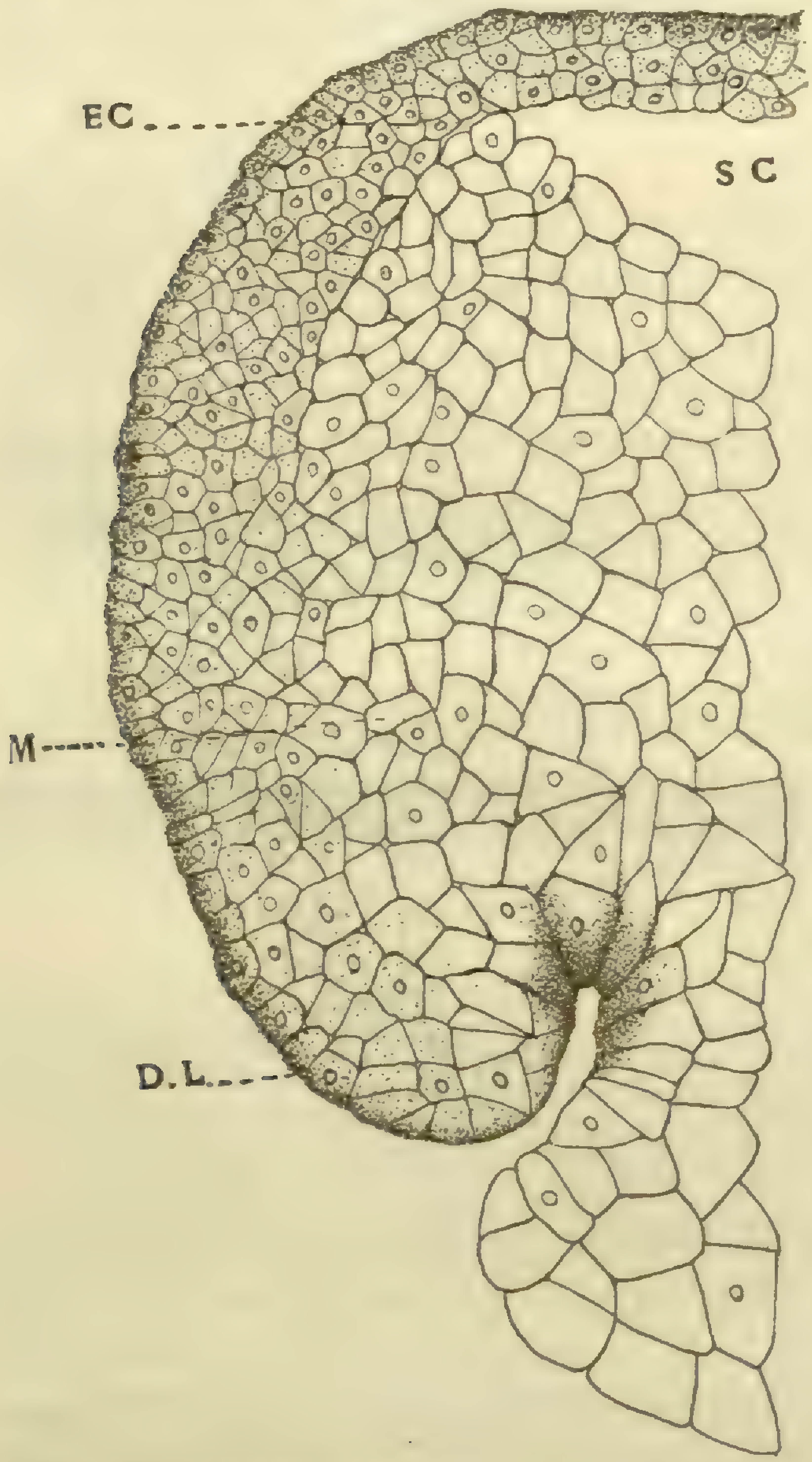

FIG. 11. — Part of a median sagittal section through the blastopore at the stage of Fig. 2. *EC.*, ectoderm. Other lettering as in previous figures.

between marginally pigmented yolk cells, then the pigment must at once almost entirely disappear on one side of the split and not on the other.

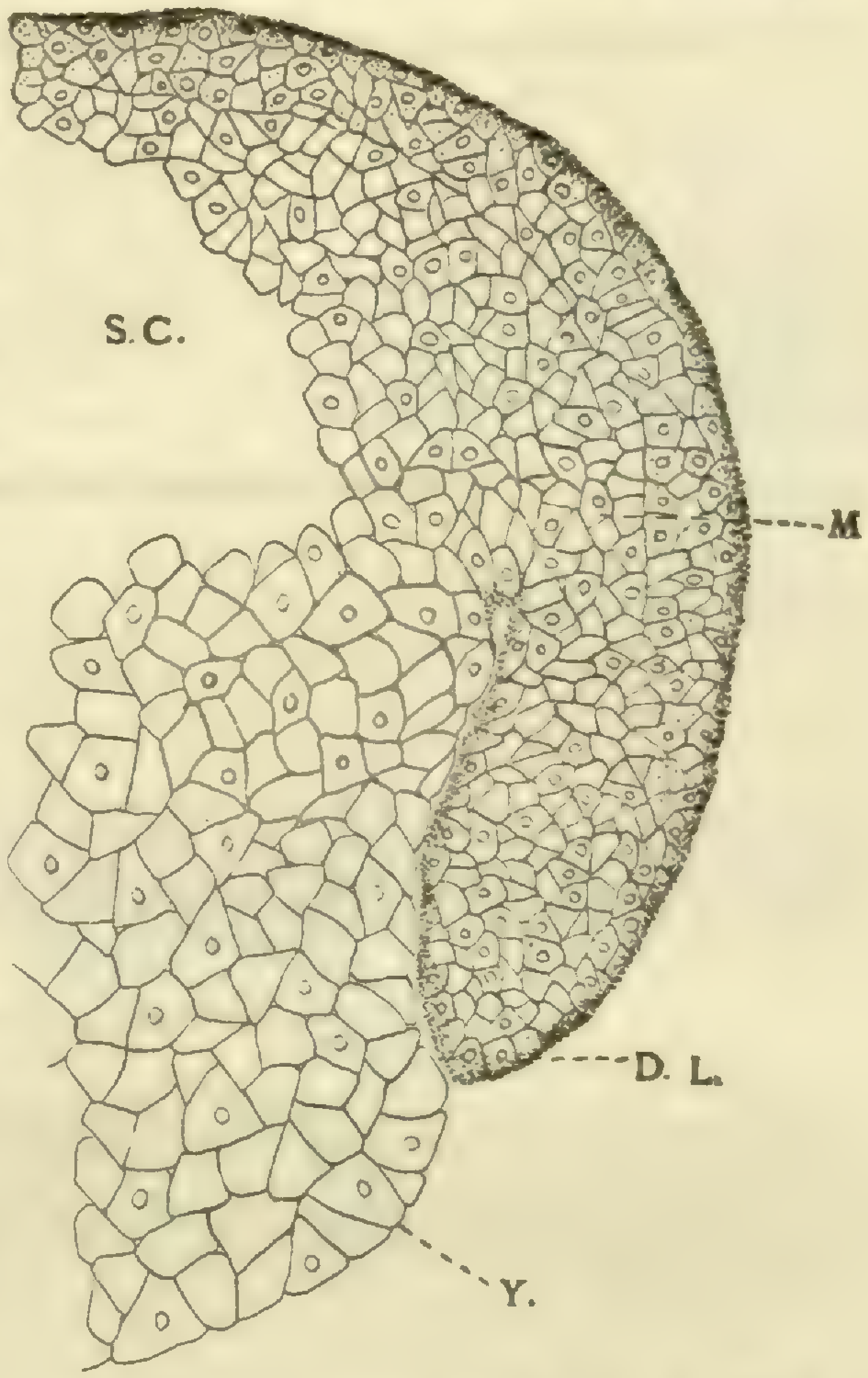

FIG. 12. — Part of a median sagittal section through the blastopore at the stage of Fig. 3. *Y.*, yolk plug. Other lettering as in previous figures.

The pigmentation at the anterior end of the archenteron in the egg of Bufo is not confined to "a double row of yolk cells" anterior to the actual cleft. Well-marked lines of pigment may extend out in any direction, even at right angles to the line of advance of the archenteron, as seen in Fig. 13. From the time that the blastopore is first formed, the pigment in the cells of the dorsal wall of the archenteron is always collected around the cell walls, never around the nucleus. Rhumbler (22) considers this phenomenon to be due to the mechanical effect of pressure. The suggestion has been offered by Jordan "that the pigment marks physiological activity, and that the less heavily pigmented cells of the ventral wall of the archenteron owe their relative lack of pigment to more sluggish metabolism attendant upon less rapid cell division." It is certainly true that the large yolk cells in the egg of Bufo divide less frequently than the cells in the upper hemisphere, but there is no evidence that the deeply pigmented cells of the outer surface of the upper hemisphere or of the dorsal wall of the archenteron divide more rapidly than the cells that are found between them. If, therefore, Jordan's suggestion is correct, some kind of

"physiological activity" other than that attendant upon rapid cell division must produce the pigmentation in these cells.

The extension of the lateral lips of the blastopore and the formation of the yolk plug have been so frequently described for other forms that a description of these processes is not necessary here, as they are apparently similar in all respects to those which take place in the frog. Following the method used by Pflüger (20), a number of eggs in the blastula stage were placed on a mirror in a shallow dish of water and the formation of the blastopore watched in mirror image. Figs. 1–8

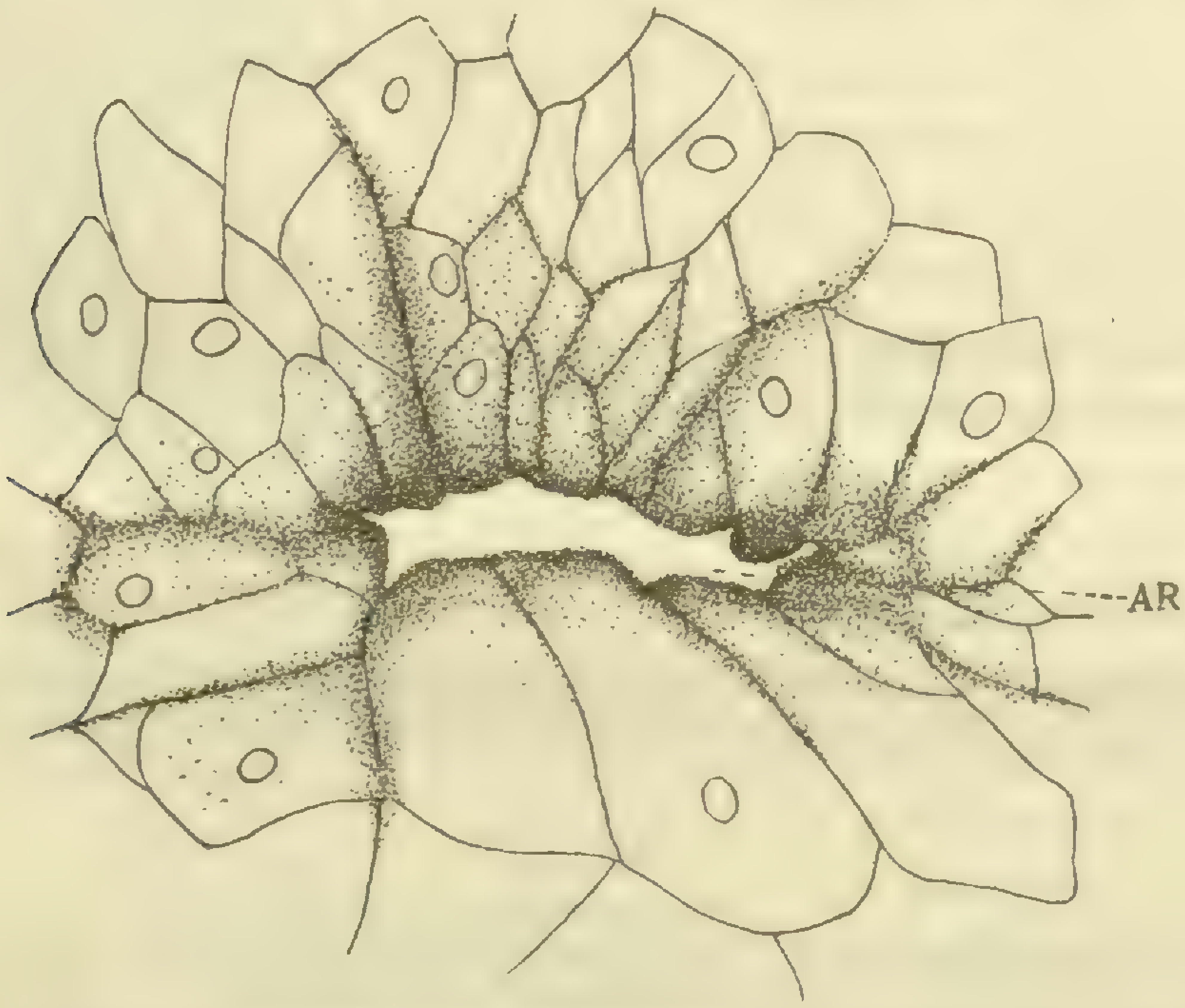

Fig. 13. — Part of a frontal section through the anterior end of the archenteron at the stage of Fig. 3, showing lines of pigment radiating out in all directions. *AR.*, archenteron.

show the appearance and the location of the blastopore at different times during the day, from 8 A.M., when the blastopore lip first appeared, to 6 P.M., when the egg began a rotation around its horizontal axis. There was no evidence to show that the position of the eggs was changed during the time they were kept under observation; on the contrary, one egg, in which a peculiar light spot was seen below the equatorial region, was watched particularly, and the spot was found to keep its same relative position until the rotation of the egg took place. These mirror images show that the dorsal lip of

the blastopore appears below the equator of the egg at the edge of the black cells (Fig. 1), and that the blastopore rim extends at a uniform rate in the form of a crescent around the lower hemisphere, until finally the yolk plug is formed (Figs. 2–4). Meanwhile, the dorsal lip of the blastopore has moved over the yolk, and seven hours after its first appearance has reached the center of the white hemisphere (Fig. 6). The closure of the blastopore lips takes place almost uniformly from all sides as a rule (Fig. 7), although occasionally the blastopore is somewhat oval when it is in the stage of Fig. 8. At or just before the stage of Fig. 8 a rotation of the egg around its horizontal axis takes place, thus bringing the dorsal lip of the blastopore back to its original position.

In its movement over the lower hemisphere the dorsal lip of the blastopore seems to pass through about 140° of the surface of the egg. There is apparently a slight variation in this respect in different eggs. This measurement is somewhat greater than that given by Morgan (16) and by Wilson (27) for the movement of the dorsal lip of the blastopore in the frog egg, and differs considerably from the measurements which have been given by other investigators. Roux (21) and Pflüger (19) estimate that the dorsal lip moves about 170°, while Kopsch (11) considers the movement to be but 75°; and this figure is further reduced by Assheton, who states that much of the so-called movement of the dorsal lip is only apparent and that the real movement is only from 60° to 70°.

The Formation of the "Germ Layers" and the Notochord.

Observations regarding the origin of the endoderm, mesoderm, and notochord in different amphibian eggs are so conflicting that apparently the most plausible interpretation of them is to assume that there is absolutely no uniformity in the manner of formation of these structures even in species that are considered to be very nearly related to each other. Such an assumption, however, can scarcely be the correct one.

Goette (6), one of the early workers on the development of the amphibian egg, considered the mesoderm in the egg of Bombinator to arise from the splitting off of a layer of cells from the primitive entoblast, the layer thus formed extending as an unbroken sheet across the dorsal wall of the archenteron. The rest of the primitive entoblast was said to form the endoderm. According to Goette, a central chord of mesoderm in the mid-dorsal region of the embryo separates from the two lateral sheets to form the notochord.

A few years later Hertwig (7), after studying the development of the eggs of Triton and of *Rana temporaria*, came to the conclusion that the mesoderm in the amphibian egg arises in the vicinity of the blastopore "durch eine paarige Einfaltung des Entoblast schon zu einer Zeit wo die Gastrulaeinstülpung noch nicht ganz vollendet ist." The amphibian egg was thus brought into agreement with Hertwig's observations on the development of other vertebrates and gave additional support to his well-known cœlom theory. A few other writers — Balfour (2), Marshall (14), and Schwink (26) — agree with the results obtained by Hertwig.

In 1888, Schultze (25), from observations on *Rana fusca*, decided that "das mittlere Blatt, sowie die dorsale Urdarmwand entstehen aus dem Ektoblast und gehen an der dorsalen Urmundlippe alle drei Blätter in einander über; in den seitlichen und ventralen Theilen des Blastoporus setzt sich die Deckschicht des äusseren Keimblattes mit besonderer Klarheit in den Entoblast, die Grundschicht des Ektoblast ohne Unterbrechung in den Mesoblast fort." Perenyi (18), from observations on the egg of *Bombinator igneus*, Lwoff (13), from a study of Axolotl and various Anura, and Brauer (3), from investigations on two species of Gymnophiona, also came to the conclusion that the mesoderm is ectodermal in origin. These investigators, however, differ somewhat regarding the manner in which this process is supposed to take place.

Perenyi states that, as a result of a turning under, or "Duplikation," of the three-layered outer wall of the egg at the lips of the blastopore, "die äussersten Deckzellen der Blastula in ihrer ununterbrochenen Fortsetzung nach innen endlich die untersten

Zellenreihen bilden werden d. h. sie verwandeln sich in Entoderm, während die anderen zwei Zellenreihen der Blastula auch in ihrer Rückwindung beisammen bleiben und eine selbständige Schichte, das Mesoderm, bilden."

According to Lwoff, "die Einwanderung der Ektodermzellen und die Verschiebung der Entodermzellen zwei verschiedene und von einander unabhängige Vorgänge sind. Die Einwanderung von Ektodermzellen beginnt an der Stelle die das Hinterende des Embryo markirt; die Verschiebung der Entodermzellen beginnt im Gegentheil im vorderen Theile. Wie die weiteren Stadien lehren, bildet das Hineinwachsen der Ektodermzellen die zusammenhängende ektoblastogene Anlage der Chorda und des Mesoderms; die Verschiebung der Entodermzellen führt zur Bildung der Darmhöhle, die infolge des Auseinanderweichens der Entodermzellen entsteht."

Brauer's investigations show that there is a turning under of the outer surface cells, or "animal cells," at the posterior end of the germ disk and that by the forward growth of these cells under the upper animal cells a blind sac is formed. This blind sac becomes the posterior part of the archenteron, and at first its dorsal wall is composed of the animal cells invaginated from the surface. In subsequent development a layer of vegetative or yolk cells grows up from either side of the archenteron and forms a layer of endoderm beneath the invaginated animal cells which later become the mesoderm.

The origin of the mesoderm in the frog's egg has been described by Morgan (16) as follows: "The cells that are to form the mesodermal layer are present at the time when the dorsal lip of the blastopore has first appeared, and even just prior to that time." The innermost of the cells forming a ring around the equatorial region of the egg where the black and the white cells meet are the cells that later become the mesoderm. "These cells are carried up to the median dorsal line of the embryo by the closure of the blastopore. They will then be found forming a layer or sheet of cells that separates itself on the outer side from the thick layer of small ectodermal cells (that has been simultaneously lifted up) and that is

separated on the inner surface, but not very sharply if at all, from the dorsal and dorsal-lateral walls of the archenteron."

In the egg of *Bufo lentiginosus*, when the blastopore first appears as a slight depression among the yolk cells just below the equator of the egg (Fig. 9), the cells which form the dorsal wall of the segmentation cavity are all small, somewhat angular cells which contain a considerable amount of pigment, particularly the cells which compose the outer surface of the egg. Near the equator the cells are found to be somewhat larger and to contain much less pigment, while in the lower hemisphere the cells are very large, and they have but a few scattered pigment granules. Up to this stage of development there is no visible separation of the cells into ectoderm, endoderm, and mesoderm. The smaller cells resulting from rapid cell division are found in the upper part of the egg and the larger cells, which divide less frequently, are grouped around the lower pole. The mass of cells marked *M* in Fig. 9 undoubtedly represent the region of the egg from which the mesoderm is formed. These cells are in no wise distinctive at this period, and their later development into mesoderm I consider to be due solely to their position in the egg during the formation and closure of the blastopore. The cells which are to become mesoderm form a layer around the egg at the equatorial region just inside the cells that are to become the ectoderm, as found to be the case in the frog's egg, according to Morgan. These mesoderm cells have many characteristics in common with the large yolk cells into which they grade, being larger, more rounded, and containing much less pigment than the small cells of the upper hemisphere. It seems probable, therefore, that they were originally produced by divisions of the yolk cells.

When the lips of the blastopore have extended so as to form a crescent in surface view (Fig. 3) a frontal section through an egg in the region of the blastopore (Fig. 14) shows that the dorsal wall of the archenteron is formed of several layers of small cells which have absolutely no distinction between them except that the cells of the outer layer, which are more regularly arranged, contain a much greater amount of pigment than the other cells. At the sides of the archenteron the innermost

of these cells pass into the large yolk cells which form the floor of the archenteron. A median sagittal section through the blastopore at the same or a slightly earlier stage of development (Fig. 11) shows the beginning of the separation of the ectoderm from the inner cells of the egg. A tolerably regular cleft extends some distance around the sides of the egg, on a line usually with the lower edge of the dorsal wall of the segmentation cavity, sharply separating the layer of cells forming the outer wall of the egg from the cells within. The separation of the ectoderm does not extend as far down as the equator of the egg at this time, and it is some hours later before

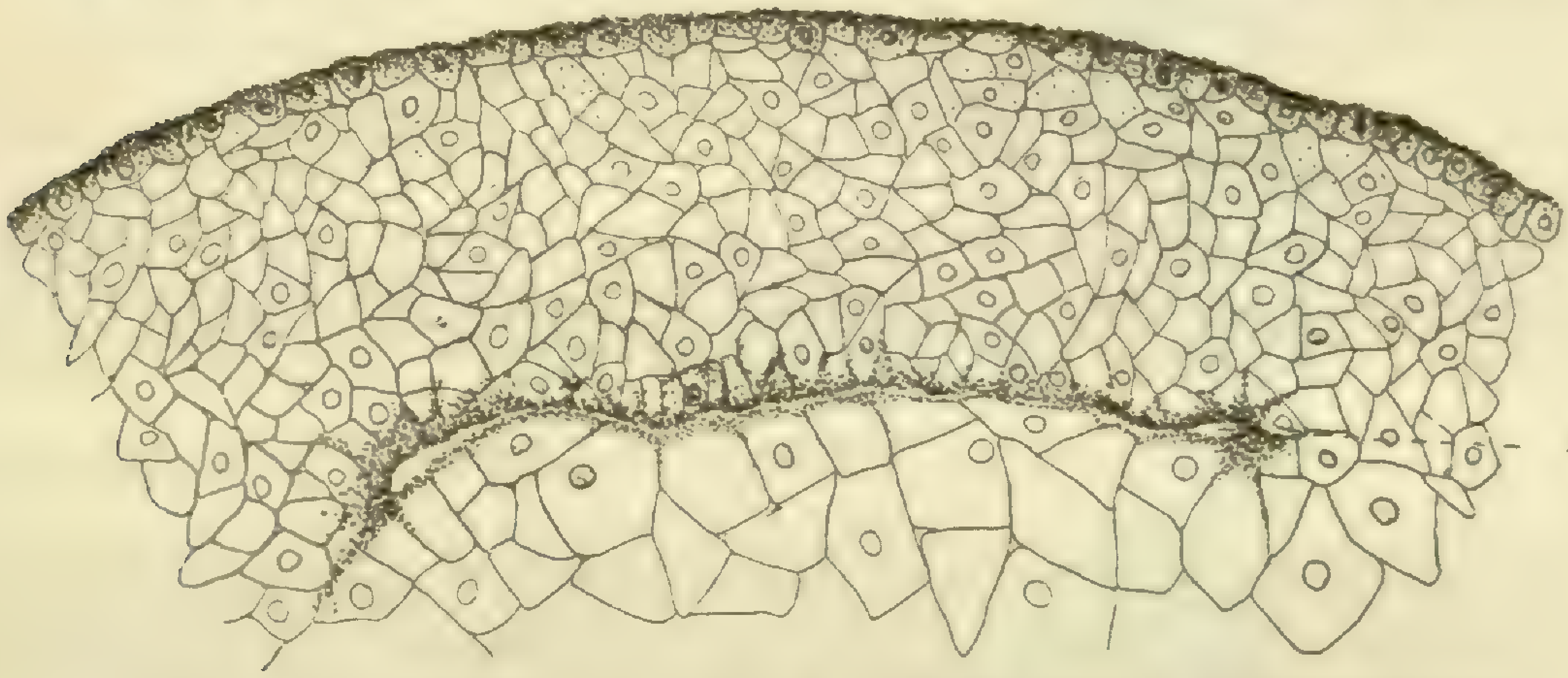

FIG. 14. — Part of a frontal section through the region just anterior to the blastopore at the stage of Fig. 3. *AR.*, archenteron.

the ectoderm at the lips of the blastopore is distinct from the other cells. It is in the region of the blastopore that the union of the different layers persists longest, as other investigators have noted.

At the stage of Fig. 3 the formation of the archenteron is well advanced, and a median sagittal section through the blastopore (Fig. 12) shows that the endoderm of the dorsal wall of the archenteron is formed of small, angular, deeply pigmented cells which, as far as I am able to determine, appear exactly like the small cells which form the outer surface of the egg. It seems probable that these cells once formed a part of the outer surface of the egg in the region just outside of the blastopore, and that they have been turned under the edge of the blastopore lip by a process of invagination, thus being changed into endoderm. Whether, in later stages of development, the endoderm

of the dorsal wall of the archenteron receives additions from the yolk, as believed to be the case by Assheton and by Wilson, I have not been able to determine.

After the ventral lip of the blastopore has formed and the blastopore is beginning to close (Fig. 6), a division of the

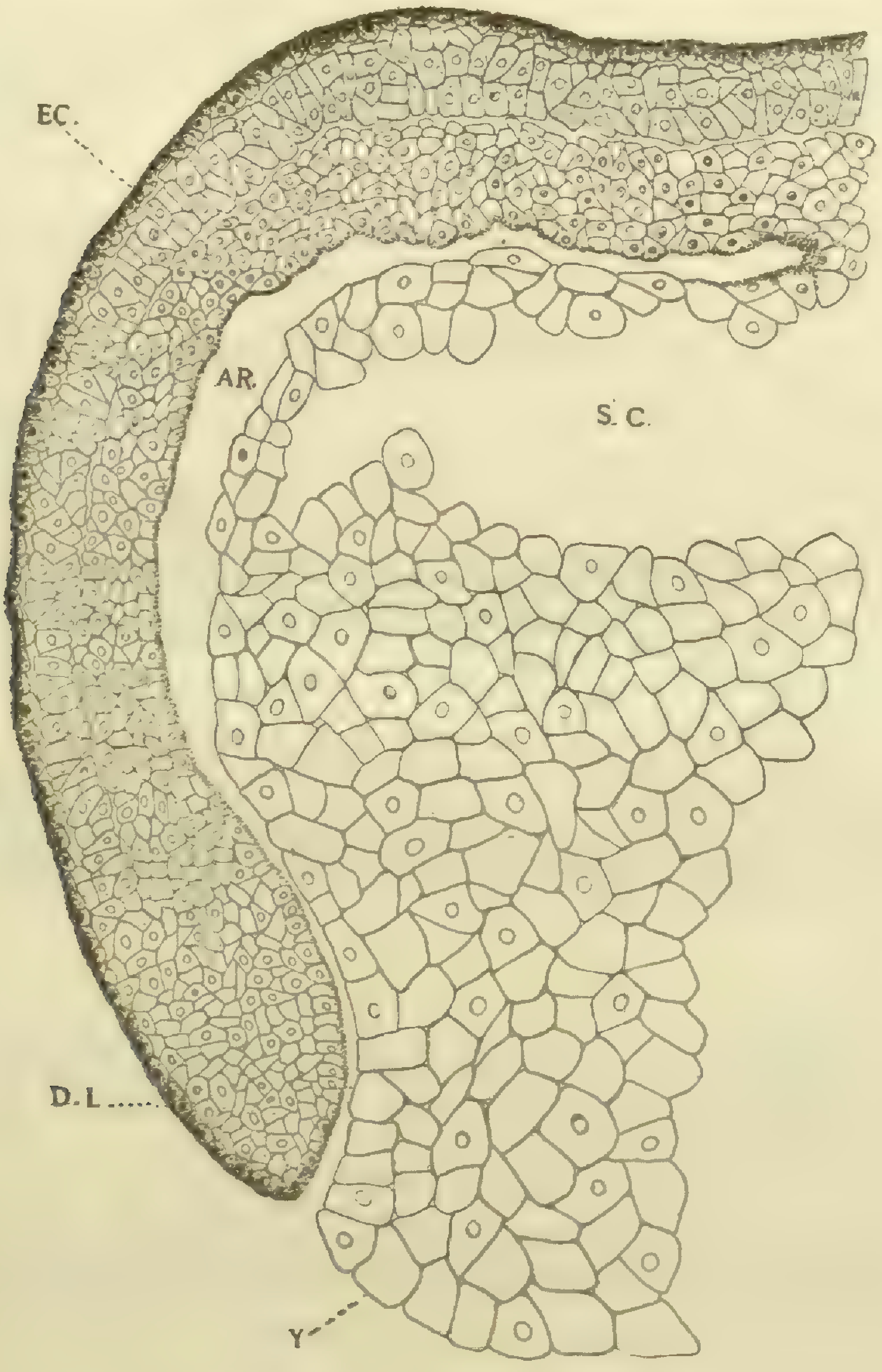

FIG. 15. — Part of a median sagittal section through the egg at the stage of Fig. 6. Lettering as in previous figures.

ectoderm into two layers is first noticed. A median sagittal section at this period (Fig. 15) shows an outer ectodermal wall composed of a single layer of small, deeply pigmented cells which are arranged very regularly. The inner ectodermal sheath is composed of two or three layers of much larger cells

which are distinctly wedge-shaped and contain a comparatively small amount of pigment. The inner layer of ectoderm is sharply separated from the mass of small cells above the dorsal wall of the archenteron.

When, in surface view, the blastopore has reached the stage of Fig. 6, or in some cases even as early as Fig. 5, a splitting is seen in the mass of cells above the archenteron, and a single layer of endodermal cells is separated from the cells above.

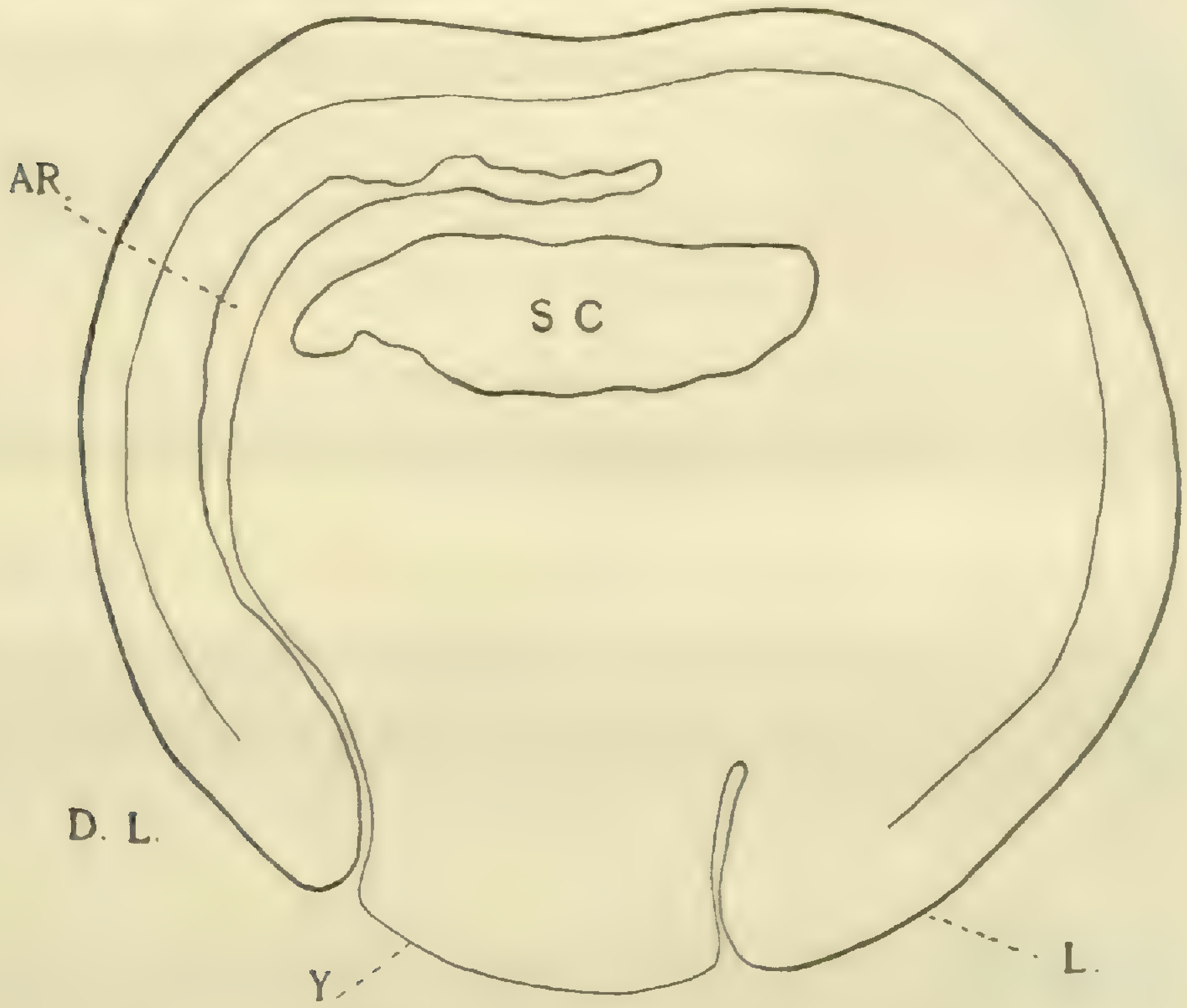

FIG. 16.—Outline of the entire section from which Fig. 15 was drawn. *L.*, ventral lip of the blastopore.

This process begins some distance in front of the region of the blastopore and gradually extends forward and backward from this point, thus completing the separation of the cells in the mid-dorsal region of the embryo into ectoderm, mesoderm, and endoderm.

When the blastopore has nearly closed (Fig. 8), a sagittal section through the middle of the dorsal lip (Fig. 17) shows that the endoderm cells of the dorsal wall of the archenteron (Fig. 17, *En.*) have flattened out considerably, and that they still contain much pigment, which is collected in the end of

the cell bordering the cavity of the archenteron. Above the endoderm is the mesoderm layer (Fig. 17, *M.*), which varies in the number of its cells in different parts of the egg. Near the dorsal lip of the blastopore the mesoderm sheath consists

FIG. 17.—Part of a median sagittal section through the egg at the stage of Fig. 8. *EN.*, entoderm. Other lettering as in previous figures.

of several layers of small cells which are not pigmented. Forward from this region the mesoderm gradually thins out until it is composed of only a single layer of rounded cells lying between the endoderm and ectoderm; then it gradually becomes thicker again, and near the ventral lip of the blastopore it appears very much as it does near the dorsal lip, being composed of several layers of cells.

A frontal section through the middle of an egg at the stage of Fig. 7 shows a single layer of mesoderm over the dorsal region of the embryo, which gradually becomes several layers thick at the sides of the archenteron (Fig. 19), and below the archenteron passes directly into the yolk cells of the lower part of the egg. Still later stages during the closure of the blastopore show that the mesoderm is unquestionably extended at the expense of the yolk cells lying just beneath the ectoderm. Soon after the medullary folds have appeared the lateral sheets of mesoderm become fused on the ventral side of the embryo; thus a continuous sheet of mesoderm is formed around the embryo, except in the mid-dorsal region where the notochord has by this time been cut off from it. The extension of the

lateral sheets of mesoderm by a process of splitting off from the outer yolk cells has been noted by Schwink (26) in *Bufo vulgaris*, by Scott and Osborn (23) and by Jordan in the newt, and by Morgan in the frog.

At the close of the blastula stage a very large segmentation cavity is found in the upper hemisphere of the egg directly under the black pole (Figs. 9, 11, 12). During the formation of the archenteron this segmentation cavity decreases considerably in size, and is pushed out of its position, coming to lie below the archenteron and being separated from it by only a thin layer of cells (Fig. 16, *S.C.*). During the closure of

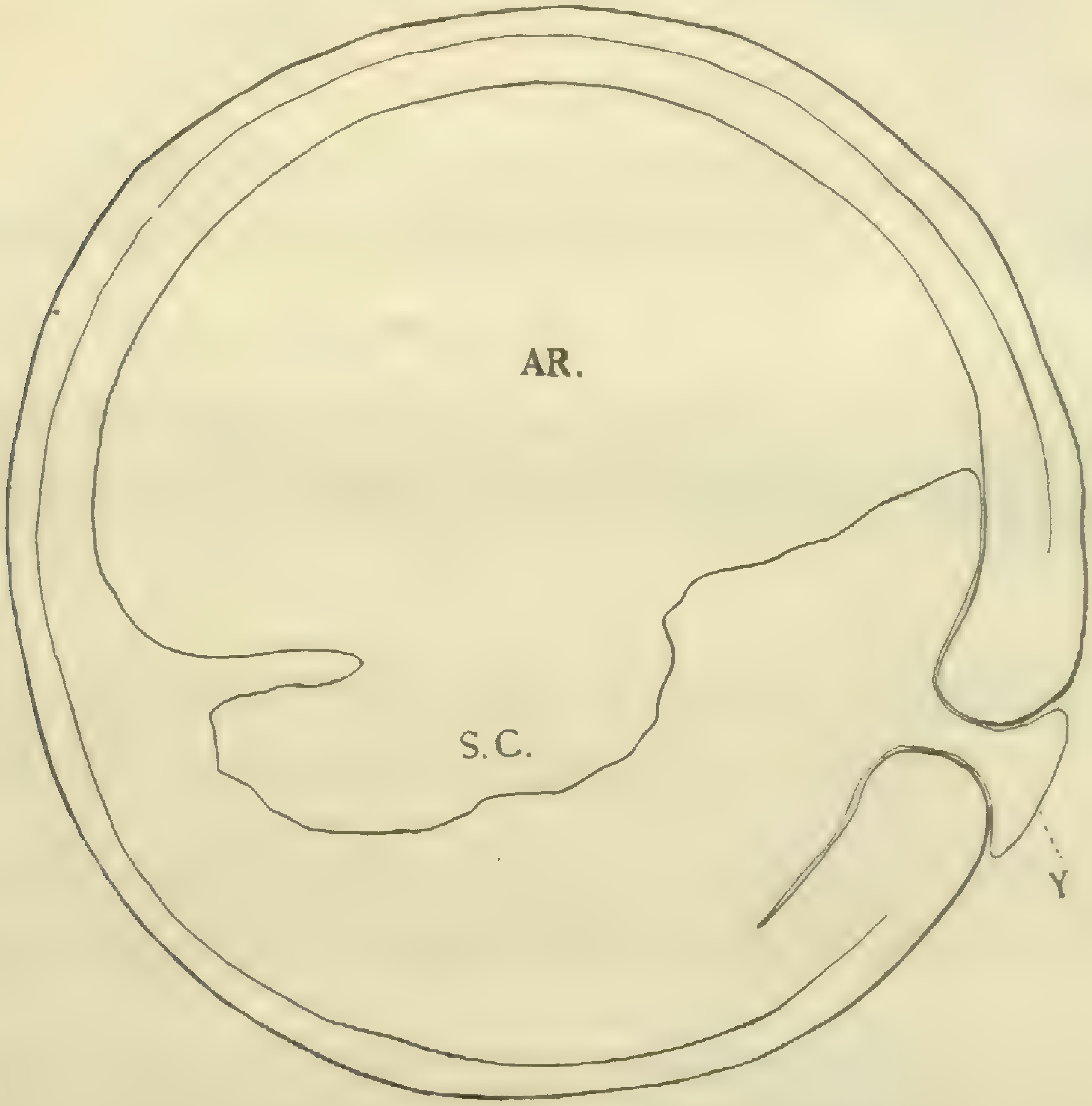

FIG. 18. — Outline of the entire section from which Fig. 17 was drawn.

the blastopore the archenteron increases greatly in size, and there is then usually but a single layer of large yolk cells between it and the segmentation cavity (Fig. 19). When the blastopore is nearly closed, I have frequently found eggs in

which there appeared to be a direct connection between the two cavities which could not be due to poor preservation of the material (Fig. 18). It would seem, therefore, that in some cases the archenteron is extended at the expense of the segmentation cavity, as supposed to be the case by Kupffer (12) and by Marshall.

A series of frontal sections through the embryo at about the stage of Fig. 7 will show the various steps in the forma-

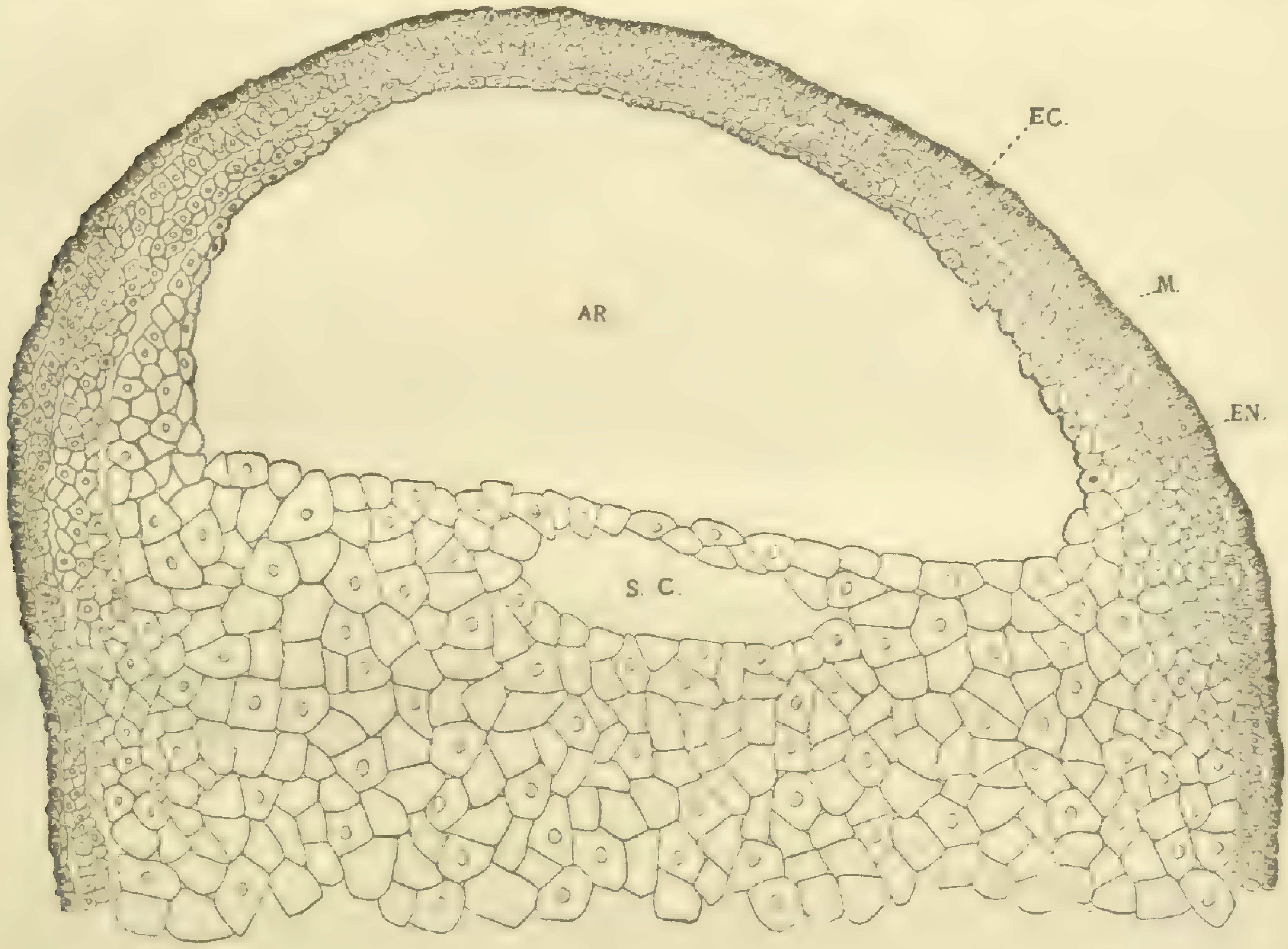

FIG. 19. — Part of a frontal section through the middle region of an egg at the stage of Fig. 7, showing the growth of the mesoderm at the expense of the yolk. Lettering as in previous figures.

tion of the notochord. A section just in front of the dorsal lip of the blastopore (Fig. 20) shows that the mesoderm in this region forms a continuous sheath over the dorsal wall of the archenteron and that it is composed of three to four layers of small cells (Fig. 20, *M.*). About eight sections anterior to Fig. 20 there is a noticeable thickening of the mesoderm in the mid-dorsal region (Fig. 21), while on either side of this thickening the mesoderm usually consists of but two layers of cells. More anterior, the thickened part of the mesoderm layer is completely separated from the lateral sheets

as a distinct rounded structure, the notochord (Fig. 22, *N.*). For only a short distance at this stage of development is the notochord entirely cut off from the mesoderm; beyond there

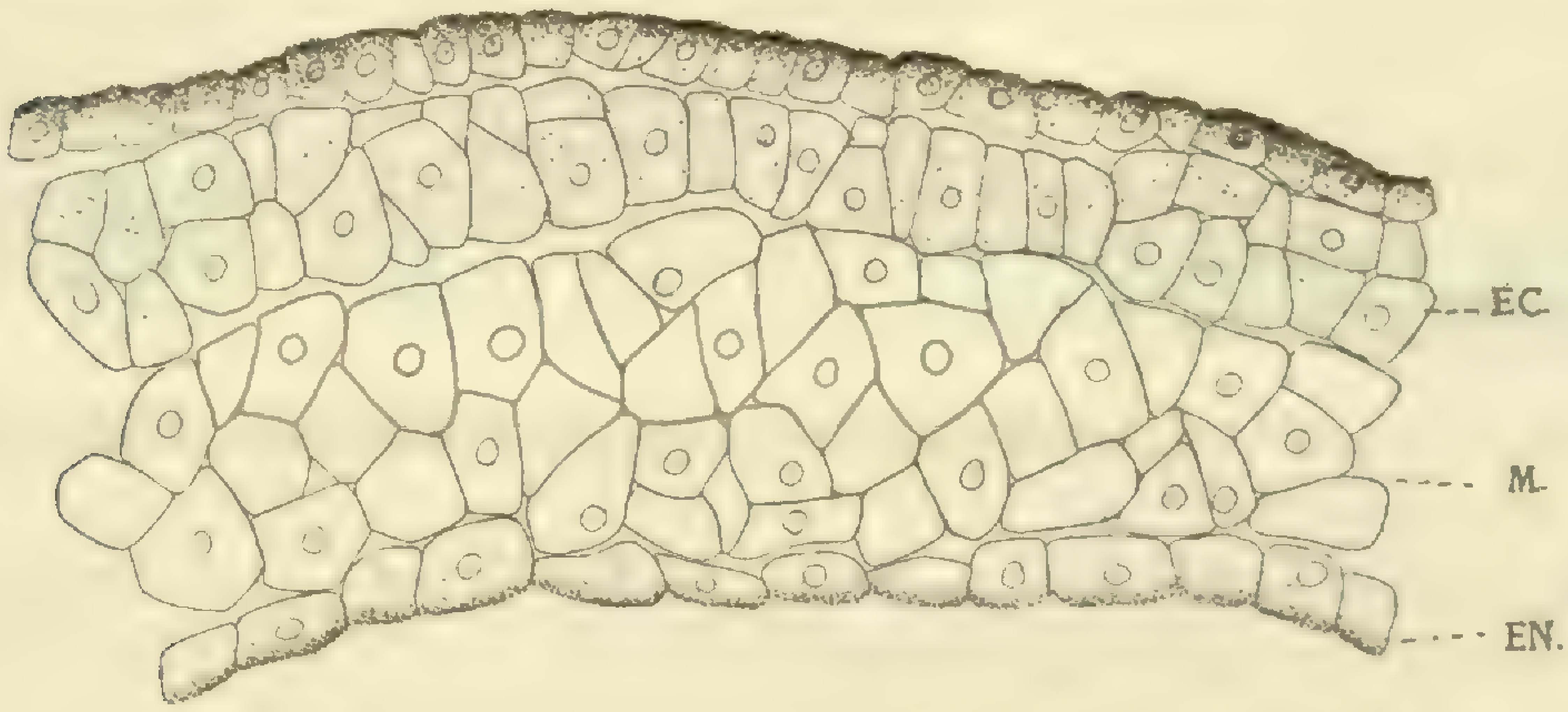

FIG. 20. — Part of a frontal section through an egg at the stage of Fig. 7, showing the mid-dorsal region of the embryo just in front of the blastopore. *EC.*, ectoderm; *EN.*, endoderm; *M.*, mesoderm.

is the same thickening of the mid-dorsal portion of the mesoderm sheet as seen in Fig. 21. In the head region of the embryo the mesoderm is thinned out to a layer one or two cells deep which shows absolutely no thickening in the middle and appears very much as in Fig. 19. After the blastopore has closed, the notochord becomes extended forward in the head region and backward in the region of the tail.

Schultze, Goette, Lwoff, Brauer, Schwink, and Morgan also believe that the notochord is derived from the mesoderm; while

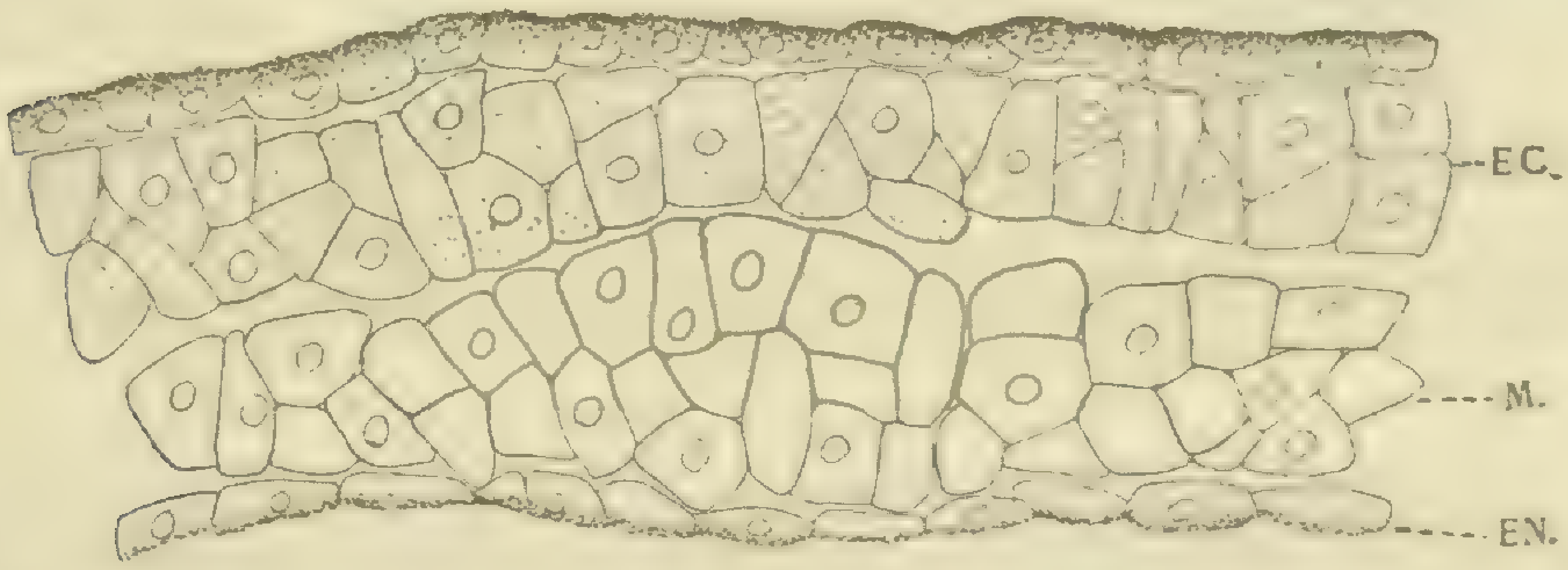

FIG. 21. — Part of a section from the same egg as Fig. 20 and slightly anterior to it. *EC.*, ectoderm; *EN.*, endoderm; *M.*, mesoderm.

other investigators consider that in the amphibians, as in other vertebrates, the notochord is endodermal in origin. Although Field (5) believes that in *Bufo vulgaris* the notochord arises

from the endoderm, in the nearly related species, *Bufo lentiginosus*, the anterior part of the notochord is certainly mesodermal in origin. After the mesoderm layer has formed, the endoderm in the mid-dorsal region of the embryo is never more than a single layer of flattened cells. There is a closer connection between the mesoderm and the endoderm above the center of the archenteron than at the sides, but I have never found an egg in which these two layers could not readily be

FIG. 22.—Part of a section from the middle region of the same egg. *EC.*, ectoderm; *EN.*, endoderm; *M.*, mesoderm; *N.*, notochord.

distinguished from each other. The endoderm cells are always much flattened at this period, and they invariably contain a considerable amount of pigment. The mesoderm cells and also the cells of the notochord are larger, more rounded, and contain but little pigment in comparison with the endoderm cells.

In conclusion, I wish to express my thanks to Prof. T. H. Morgan for advice and criticism during the progress of my work.

BRYN MAWR COLLEGE, BRYN MAWR, PA.,
December 16, 1901.

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NOTES ON THE CŒLENTERATE FAUNA OF WOODS HOLE.

CHARLES W. HARGITT.

THE following notes upon certain faunal features of the cœlenterate life of Woods Hole and adjacent waters pertain chiefly to the season just past, including records which are fairly constant at regular intervals throughout the entire year. For certain of them I am indebted to Mr. Vinal Edwards, whose painstaking records during many years are matters well known to many naturalists. I am also under obligations to Mr. George M. Gray and Dr. H. M. Smith for similar favors. In addition to notes upon the seasons, habits, etc., brief accounts are presented of new forms discovered and of the development of one of the Scyphomedusæ.

HYDROMEDUSÆ.

A New Tubularian Hydroid. — In August, 1900, while cruising and dredging in Muskegat Channel off Marthas Vineyard, a considerable number of fine specimens of *Corymorpha pendula* Ag. were taken by dredge and trawl, many of which were in fine condition, still imbedded in the sand as in normal life. A somewhat cursory examination of the specimens showed what seemed to be young specimens growing among the filamentous rootlike holdfasts and apparently budding from the base of the hydroid, like young polyps, reference to which fact was made by the present writer in the recently published synopsis of Hydromedusæ. In order to determine more definitely the apparent anomaly of buds arising from so low among the rhizoids and below the sandy surface of the substratum, and whether they might show signs of later becoming detached, the specimens were submitted to one of my students, Mr. A. J. May, with instructions to determine the range of budding, nature of

development, etc. The results have shown what was only at first dimly suspected, namely, that the small "buds" were in fact not buds at all, but a distinct hydroid, apparently parasitic, growing upon the base of the Corymorpha. This was clearly demonstrated both from the specific differences which a critical study of its morphology showed, and by means of sections made through the points of attachment. The point of attachment is within a rather limited zone of the base, among the conical papillæ and filamentous rhizoids of the host, where in some cases as many as half a dozen were growing upon the same specimen. As will be noted from Figs. 1 and 2, the new hydroid clearly belongs to the genus Tubularia, having the characteristic form of body, arrangement of tentacles, etc. Its attachment to the host was quite close, being inserted within the filmy perisarc, where its base expanded in the form of fingerlike absorbent organs.

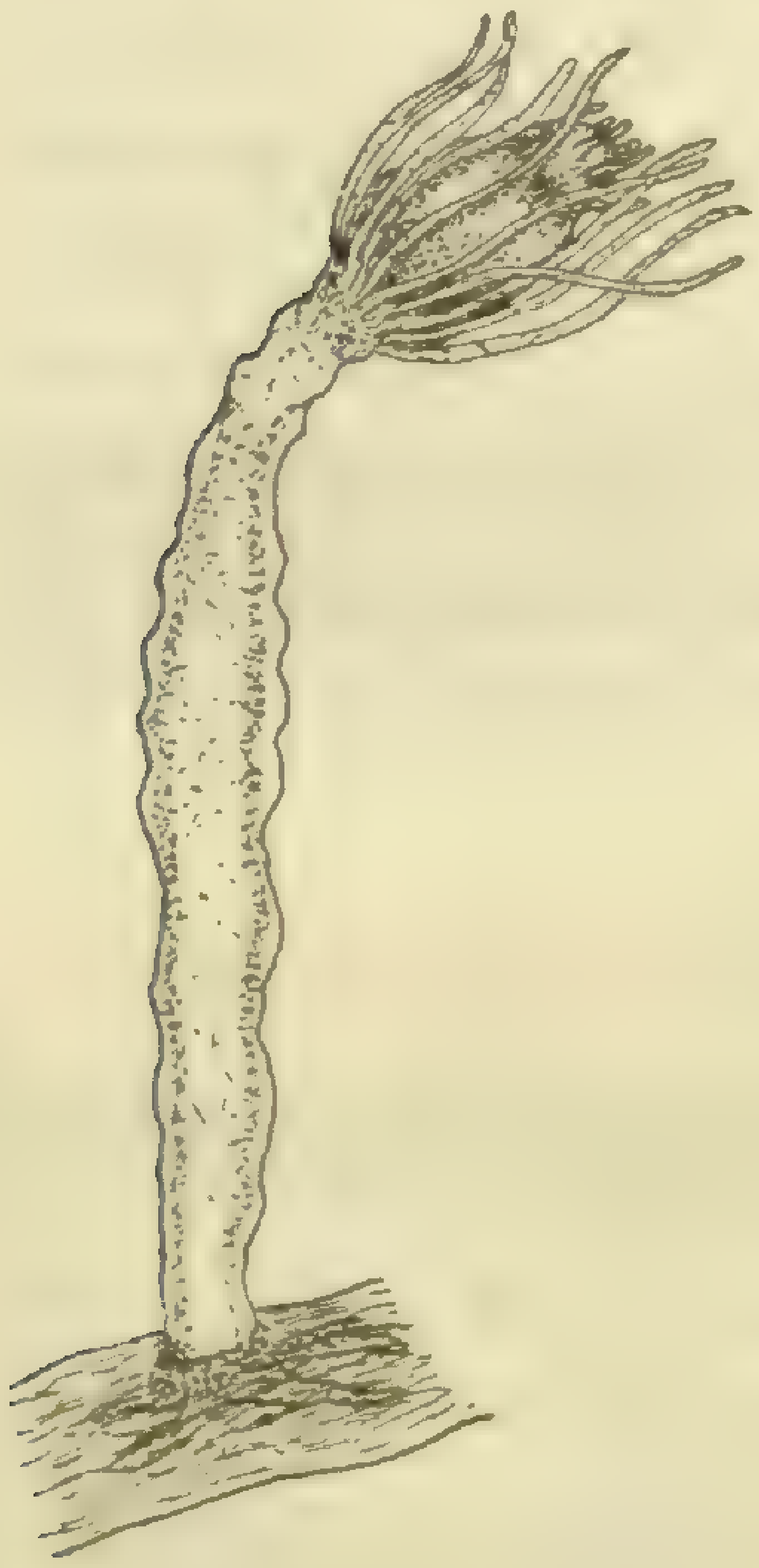

FIG. 1. — Tubularia parasitica.

Briefly its characters may be summarized as follows: Hydranth solitary, from 2 to 5 mm. in height and about $\frac{1}{3}$ mm. in diameter; tentacles in two whorls, the proximal of from eight to sixteen, the distal of from five to eight. Gonads were found upon but one specimen, and in this were immature, but occupying the characteristic position among the basal tentacles. So far as known, semi-parasitic upon Corymorpha. I propose for it the provisional name *Tubularia parasitica*, till further investigations may be had upon additional and more mature specimens, which may further confirm or modify this description.

A New Hydromedusa. — On Aug. 10, 1901, a medusa with distinctively sarsian characters was taken in the tow, similar in many respects to two species described by Forbes in 1848 (British Naked-Eyed Medusæ), chief among their features being the proliferous development of medusæ from the body or manubrium of the parent medusa. Haeckel likewise described a similar medusa

from the Canary Islands, in which secondary medusæ were budded in great numbers from the very long siphonlike manubrium. So far as I am aware, no member of the genus Sarsia having similar characters has been described from American waters.

Forbes's species were *Sarsia gemmifera* and *S. prolifera*, as cited above, pp. 57–59. The former, like Haeckel's *S. siphonophora*, buds its secondary medusæ from the walls of the long manubrium in a spiral-like raceme throughout its entire length. In the specimen under consideration the proliferous medusæ are budded from the manubrium, but in a whorl about its base (cf. Fig. 3). Only a single specimen was taken, but its characters were so definite that there seems little doubt as to its specific distinctness.

Fig. 2. — Corymorpha pendula Ag. with Tubularia parasitica.

The following characters summarize its more distinctive features: Bell high, somewhat ovate, or elongate hemispherical; tentacles four, with prominent basal bulbs, orange-colored, with marginal fringe of delicate green, each bulb with a prominent ocellus densely black and facing outward. Manubrium long, pendulous, extending far beyond the margin of bell, capable of great contraction; terminal portion doubly bulbous, with proximal bulb light sky-blue, terminal green; basal portion of manubrium expanding into an orange-colored gastric pouch which graduates into the body of the bell. Gonads medusoid, in a whorl about the base of the manubrium; ectoderm transparent or faintly tinged with pale blue, entoderm orange-colored. Height of bell, 1.5 mm.; breadth, 1 mm.

For this medusa the name *Coryne producta* is proposed. The description is based upon a single specimen, and while its characters seem sufficiently definite to warrant specific distinction, it is not impossible that other specimens in larger numbers may necessitate modification or change at certain points.

SEASONAL ASPECTS.

The seasonal range among medusæ is noteworthy in many cases, both by reason of its periodicity in certain species and by its perennial character in others. The following are among the distinctively spring medusæ.

Hybocodon prolifer Ag. is one of the most restricted in this respect, ranging from late February to about the middle of May. It is one of the most beautiful and brilliant of the early medusæ. Its proliferous budding of secondary medusæ from the large single tentacle is an interesting and well-known feature. I have also found it producing actinulæ from the walls of the manubrium at the same time. These seem to arise much as do similar larvæ, from several other anthomedusa, and a histological examination shows essentially similar features of oögenesis and spermatogenesis, though there is no appreciable distinction of sexes so far as morphological features are concerned.

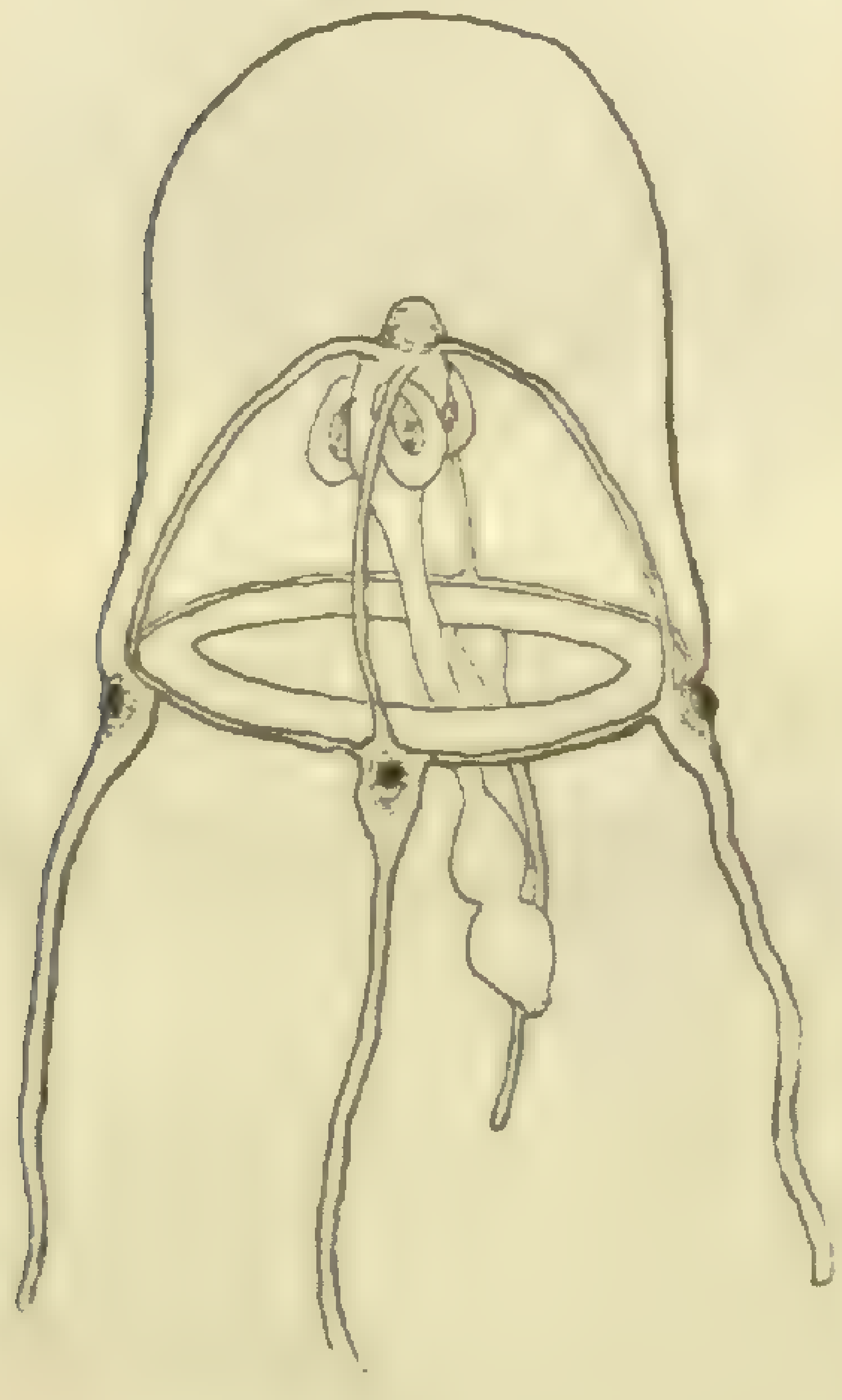

FIG. 3. — Coryne producta.

Tiaropsis diademata Ag. This is likewise an early medusa. According to Agassiz, "one of the earliest visitors of our wharves in spring." During the present season it has been taken from March 20 to May 1, though only in limited numbers.

Coryne mirabilis Ag. is also one of the earlier medusæ, but with a longer range, from February to May. It has been reported by Fewkes as occasionally taken at Newport in early summer.

Lizzia grata A. Ag. Of this medusa I have records during the present year from March 27 to April 29. Fewkes has reported it as occurring at Newport during the entire summer, but this would seem to be somewhat unusual.

Tima formosa Ag. This beautiful medusa, one of the largest of the early Hydromedusæ, while not specially rare at

this station, is not specially abundant. Its season is comparatively brief, ranging from April 12 to May 5. While sometimes quite abundant at certain localities, its hydroid phase is as yet unknown, as is also its development.

Trachynema digitale A. Ag. This Trachomedusa is occasionally taken here in considerable numbers in April, but is not a common medusa. Little appears to be known as to its habitat or life history, but it is probably more or less pelagic, and hence subject largely to the influence of ocean currents, etc.

Rhegmatodes tenuis A. Ag. Note is made in this connection of the occurrence of this medusa in large numbers during the summer of 1900, the first record during several years, and its utter absence during the present season. It is usually recognized as a summer medusa, and the present record only confirms this. What is more specially worthy of note is the erratic aspect of its appearance, apparently at long intervals, and then usually in great numbers, indicating seemingly some local or environmental condition as governing its occurrence, rather than purely seasonal mutations. Were Rhegmatodes a pelagic medusa we might account for mutations of this sort through the agency of shoreward currents or winds, as often happens with Physalia, and perhaps also with Trachynema, as intimated above. But so far as I am aware, this medusa, in common with most of the Hydromedusæ, is more or less restricted to the littoral fauna, and hence only incidentally affected by such influences. This is another medusa whose hydroid yet remains unknown. Possibly when its life cycle is fully known the apparent capriciousness of its occurrence may be cleared up.

Staurophora laciniata A. Ag. was likewise taken in considerable numbers in early May by Mr. George M. Gray, and later in the month by Dr. H. M. Smith. So far as my records are concerned, this is the first occurrence of this medusa in several years at this station. One of its peculiar structural features, the early confluence of the oral lobes with the frills of the gonads, so that they can only be distinguished with difficulty, was described by A. Agassiz. No mention, so far as I am aware, has been made of the origin of actinulæ in this

medusa by a method very similar to that of Hybocodon. In Staurophora, however, they arise within the greatly folded borders of the gonad pouches beneath the radial canals. As in the former, no conspicuous differentiation of sex was apparent in Staurophora, though not having seen them alive, and not having as yet examined the histology of the gonad region, this can only be stated tentatively.

Among medusæ taken during midsummer, the more common were *Nemopsis bachei* Ag., very abundant during August; *Bougainvillia carolinensis* Ag., likewise abundant during August; *Pennaria tiarella* McCr., less abundant than during previous seasons; *Ectopleura ochracea* A. Ag., unusually abundant during August, taken mostly in the evening tow; *Eucheilota duodecimalis* A. Ag., *Eucheilota ventricularis* McCr., not uncommon during August; *Eutima limpida* A. Ag., fairly common, but sexually immature; *Lafœa calcarata* A. Ag., not uncommon, and in many cases the several phases in the development of the medusa were taken. *Dipurena conica* A. Ag. and *D. strangulata* McCr. were taken, but from a comparison the specimens so intergraded as to suggest a probability of their specific identity, with only varietal differences.

Of rarer medusæ the following were taken: *Willia ornata* McCr., taken in considerable numbers at various times during the summer, were evidently breeding, as medusæ of all sizes and stages of development were found; *Podocoryne carnea* Sars, taken sparingly; *Epenthesis folcata* McCr., not numerous, colors less brilliant than those figured by Mayer for this species. Species of Obelia were notably few during the present summer, in rather sharp contrast with previous records. It is one of the few medusæ with a record extending throughout the entire year and often occurring in immense numbers, this latter being common with many species of Obelia.

SCYPHOMEDUSÆ.

These medusæ were more than usually abundant during the summer, a thing not common at Woods Hole except very early. Many specimens of Aurelia, Cyanea, and Dactylometra

were taken about the docks of the fish commission during July, and even August, which were sexually mature, and from some of which ova were obtained and the development followed as described below. That these were not an isolated few left over from the earlier numbers of April and May is evident in that many were taken in the open waters of Vineyard Sound, and even in the open sea far from land in the region of the Gulf Stream, mostly of the genus Cyanea. They may have been caught up by southward currents from a more northern locality along the coast of Maine or beyond, and carried to these southern ranges.

Specimens taken into the laboratory and placed in aquaria discharged developing ova in great numbers, literally covering and packing the bottom of the aquaria. The following synopsis of the development of Cyanea may not be without interest as having been carried on under the wholly artificial conditions of the aquarium, from the later cleavage of the egg on to the freeing of the ephyræ, — a circumstance not hitherto recorded, so far as I am aware, though Bumpus has recorded the fact that earlier phases occur readily under such conditions, and both McMurrich and Hyde likewise refer to the same fact, but they do not seem to have succeeded in tracing the entire development.

The early cleavage phases of Cyanea are passed while the ova are still within the gastric cavity or while "nursed" within the ample folds of the manubrium or frilled oral margins. A typical blastula results from total and regular cleavage and appears to be followed by an early gastrulation and the prompt obliteration of the blastopore.

Soon after this, and while the larvæ are still within the egg membrane, cilia are developed, and they may be seen slowly rotating within the membrane, which, however, is early ruptured and the embryo escapes as a free-swimming organism. In shape it is at first almost spherical, but soon takes on the oval or pyriform shape characteristic of most planulæ. Details as to the origin and differentiation of the endoderm are not yet worked out, but they seem to conform rather closely with the observations of Hyde and the later conclusions of Smith

on Aurelia, as well as with the recent work of Hein on the same form.

The larval history seems to vary greatly as to matters of growth, transformation, etc. A few specimens attached themselves to the bottom of the aquaria in from six to ten days and promptly assumed the typical scyphistoma stage, while others were swimming planulæ at the end of as many weeks, showing no tendency toward transformation.

Encystment. — Both McMurrich and Hyde have recorded an encysting phase in the life of the planula preceding metamorphism. Hyde noted, however, that in one series of experiments this did not take place. My own observations have probably sufficed to reconcile these discrepancies by showing that it is incidental rather than essential, — a mere adaptation to changed conditions.

That encystment may and does occur under certain circumstances is not in the least doubtful, if not indeed a more or less common phenomenon in development under artificial conditions. A very considerable proportion of my own specimens passed through such a stage, which varies from a few days to many, and is, indeed, often a permanent and fatal one; but, on the other hand, it is not less certain that many passed through the metamorphoses without the least sign of encystment, while in others there was the aspect of incipient encystment common in many hydroid planulæ, namely, the secretion of a delicate perisarc-like sheath over the base of the planula in the process of attachment. There seems little doubt, therefore, that in these variable aspects we have the clue to the entire matter, so far as these larvæ are concerned, and may consider encystment, as above intimated, to be an adaptation against unfavorable conditions, and therefore comparable with the same phenomenon among Protozoa and other organisms. May it not hint the probable phyletic origin of the perisarcal structure so largely characteristic of one class of cœlenterates, to which the facts under consideration may show more or less definite reversion?

The Scyphistoma. — The young scyphistoma is at first of vasiform shape, the base small and adherent by the delicate

film of horny secretion referred to above. The primary tentacles are usually four in number and arise as small buds from the broad oral end of the polyp about the same time as the mouth is formed. In many cases the number varies, only two arising at opposite sides, two others following at intermediate positions. More rarely only three tentacles occur in the primary set, followed by three others likewise in intermediate positions, giving the polyp at first a trimerous and later a hexamerous aspect, — a condition usually associated with the phenomenon of a triangular mouth which continued even during the entire history of the polyp. In several cases bifurcated tentacles occurred, and continued during the scyphistoma stage. The average number of tentacles is sixteen, though this may also vary considerably, many specimens being noted with twenty or more. The scyphistomæ of Cyanea are almost clear white in color, in rather marked contrast with the dull flesh color of the polyp of Aurelia, and when viewed in colonies against a black background present a most beautiful picture.

Stolonization. — This is a much less common feature in Cyanea than in Aurelia, though not by any means rare. Stoloniferous processes may arise from the bases or sides of the polyps, and growing laterally may become attached and serve as points of origin for new buds. They are, however, fewer in number and give rise to no such complex colonies as are frequent in polyps of Aurelia. No cases of the direct origin of secondary polyps from the body of the parent were noted in the case of Cyanea.

Strobilization. — Owing to the small size of the polyp of Cyanea, strobilization is comparatively inconspicuous and was only at first noted about the time the fully formed ephyra rendered the fact evident and directed attention to it. The segments are few in number, in many cases a single one only occurring at a time, though three or four are not unusual; but in no case were more than five noted upon any given specimen. In the cases of polystrobilous specimens the basal portion seemed to renew its activities, new tentacles arising and the specimen showing every indication of healthy development,

probably later strobilating as before, though no demonstration of this was undertaken.

The time involved between the attachment of the planula and the assumption of the strobila stage and the discharge of ephyræ was like that of the planula history, quite variable. The minimum time noted between the attachment of the planula and the assumption of the strobila stage was ten days, making the time from the origin of the planula to that of the strobila about seventeen days, or about eighteen to twenty days for the appearance of the ephyra. But as before intimated, there is much variation on this point, probably more than occurs in natural conditions.

The Ephyra. — Ephyræ liberated in the aquarium seemed quite normal in morphological aspects. In color they are dull brownish, the color showing itself as the strobilization proceeds toward maturity. In habit the young ephyra appears somewhat sluggish, and, while capable of active movement by the contractions of its bell, lies rather quiescent in the aquarium, seldom moving except as stimulated by agitation of the water or otherwise. While in rest it lies upon the aboral surface, with the manubrium extended upward, probably a condition assumed for the capture of prey.

Several specimens were marked by definite variation in the number of lobes or other organs. A specimen with nine lobes had also a similar number of rhopalia, while another with eight normal lobes had three extra rhopalia irregularly disposed at intermediate positions. Several specimens taken in the tow showed also similar variations, as did likewise several adult specimens taken during the summer and at previous times.

Feeding. — In rearing the polyps several experiments were made upon the feeding habits. Scrapings of slime, algæ, etc., from the eelgrass, which contained numerous Protozoa, were found to be among the most successful sorts of diet. Larvæ of gastropods and starfish were also taken readily by the polyps, the former especially being apparently quite acceptable. Diatoms and other micro-organisms taken from the deep waters of the Sound apparently proved deleterious, the polyps in aquaria supplied with this food showing evident and

rapid decline of vigor and health. In small aquaria numerous cases of cannibalism were noted, the scyphistomæ greedily devouring any planula which came within the grasp of the vigilant tentacles, the entire process of engulfing the victims being several times observed.

A Cubomedusa from Woods Hole. — Several specimens of an interesting medusa of this order were taken in the tow, the first on August 13, in Great Harbor, a second the following day at North Falmouth, Buzzards Bay. Two or three others were taken within the next day in Great Harbor.

In general features the medusa resembles very closely one figured by Mayer from the Tortugas (*Bull. Mus. Comp. Zoöl.*, Vol. XXXVII, No. 2, p. 70), and to a less degree a medusa described by Fewkes from the Bermudas (*Bull. Mus. Comp. Zoöl.*, Vol. XI, No. 3). In many respects, however, it differs from both, namely, in its larger size, deeper color, apparent absence of gastric filaments, figured by Mayer. Both Fewkes and Mayer consider the specimens taken by them as immature, and their identification was accordingly somewhat doubtful, the former assigning his to the genus Tamoya, the latter referring his, together with that of Fewkes, to the genus Charibdea. Certain it seems that unless the specimens are immature they could hardly be included within either genus, or indeed within any other of the at present recognized genera of the family. The absence of velar canals and pedalia, as well as the very short tentacles, would of themselves be sufficient to exclude them.

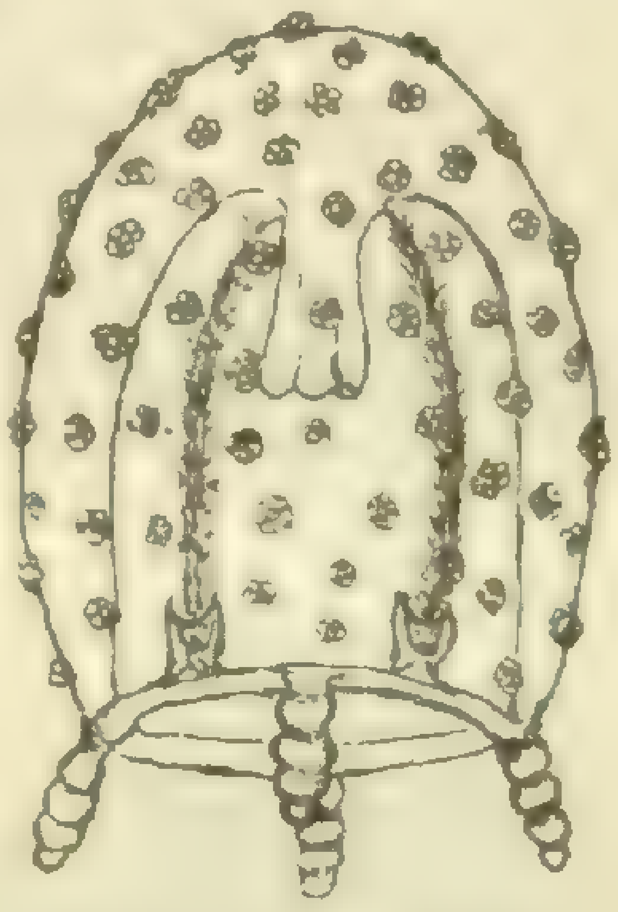

FIG. 4. — Charibdea verrucosa.

The same is likewise true of the specimens under consideration. They are so nearly identical in morphological features, size, etc., as to suggest something like maturity, unless, perchance, they should be indigenous species, — an exceedingly doubtful supposition. If borne hither from the Tortugas or Bermuda by currents, it would seem that the time involved in transit should have given at least some differentials of size or other peculiarity.

The following descriptive characters may serve to show in how far they fail to conform to the type characters of the genus: bell ovoid in profile, cuboid as seen from either pole; size from 2 to 3 mm. in short diameter by 4 to 5 mm. in height. Color a dull amber, somewhat translucent; exumbrellar surface dotted irregularly with light brownish warty clusters of nematocysts. Tentacles brown in color, rather short and spindle-shaped, with deep annulations. Rhopalia four, radially located, set in rather deep pockets somewhat above the level of the margin, each with several ocelli near the tip. Velarium well developed, and strengthened by four frenulæ or thickenings of the subumbrella in the region of the radii. Absence of any traces of velar canals is noteworthy, as is likewise absence of mesenterial filaments. Distinct gonads could not be distinguished, though sections showed a genital region and ova in process of development. Manubrium well developed, quadrate in form. In case the specimens may be referred to the genus Charibdea, it must be upon the assumption of immaturity, as Mayer has suggested, in which case they compare fairly well with Mayer's *C. aurifera*, though in size somewhat larger and more brownish in color. If, as seems not unlikely, they must be given specific distinctness, I would propose for the species the name *verrucosa*, as significant of the *warty* knots of nematocysts which adorn the outer bell.

The Zoölogical Laboratory,
Syracuse University, May 1, 1902.

THE BODY SENSE HAIRS OF LEPIDOPTEROUS LARVÆ.[1]

WILLIAM A. HILTON.

It is well known that, as a rule, all arthropods have their bodies and appendages clothed with hairs, or setæ, which are simply modified parts of the cuticle.

These hairs vary in form and in structure. In the most common type the hair is hollow, and its lumen communicates with the body cavity by means of a "pore canal" in the cuticle (Fig. 1). Through this pore various structures may extend into the lumen of the hair, as a prolongation of a hypodermal cell, gland ducts, and nerves.

There are published references to solid hairs of insects; but if we except certain minute elevations of the cuticle, such as are represented in Fig. 2, and which are more or less hairlike, I found none in the insects studied. It should be said, however, that certain scalelike appendages of the cuticle of the larva of Corydalis (Fig. 3, *h*) appear to be solid; but as these occur, each at the end of a pore canal, they may prove to be hollow.

The most commonly observed structure that passes through the pore canal into a hollow hair is a prolongation of a hypodermal cell, which is much larger than the ordinary cells of the hypodermis (Fig. 4, *t*). Such a cell was named a "trichogen," by Graber, as it is believed to be the element that produces the hair. In many cases there are associated with the trichogen one or more gland cells, which discharge their secretion through the hair; the stinging hairs of certain larvæ are examples of this type. Such hairs may also have a nerve extending to them, and perhaps they always do.

A type of hollow hair which occurs much more commonly than does the glandular hair is one into the lumen of which

[1] *Contribution from the Entomological Laboratory of Cornell University.*

there extends only a trichogen cell and a nerve. The larger number of the organs of special sense of arthropods are hairs of this type, more or less modified. Frequently, however, the modification has been carried so far that the organ of special sense is not at all hairlike. This is especially true of many of the supposed organs of taste and of smell. I have made no attempt to study these.

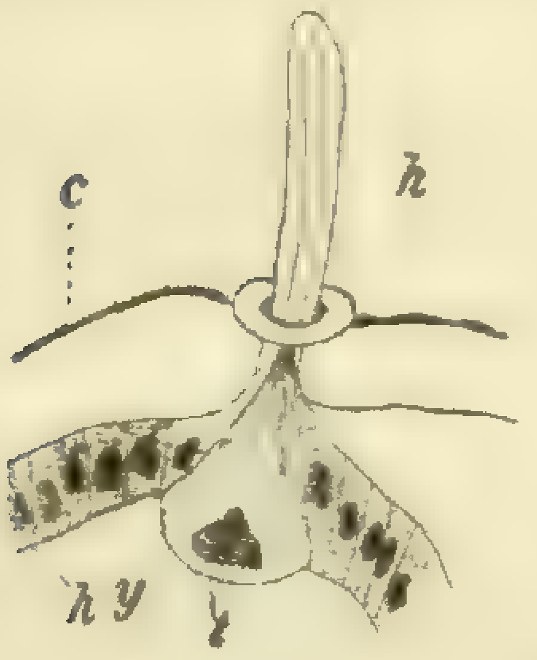

FIG. 1. — Simple hair from the silkworm (*Bombyx mori*).

The investigation, the results of which are given in this paper, was confined to a study of those hollow hairs, or setæ, which are distributed over the surface of the body and are believed to be organs of touch. The primary object of this investigation was to determine as definitely as possible just what type of hair on the body surface is a sense hair; a secondary object was to determine in what ways this type is modified in various lepidopterous larvæ. Some work was also done on several other orders of insects, with the result that a close correspondence was found in the structure of these hairs among even widely separated orders.

METHODS.

In order to definitely demonstrate which hairs were sensory it was necessary to have recourse to special histological methods, as the terminations of the nerves for touch in insects are exceedingly delicate, and the usual microscopical methods are entirely inadequate for the successful differentiation of the nervous tissues. For general anatomy of the sense hairs the usual fixing and staining fluids were used; but for staining the peripheral nerve fibers and cells the *intra vitam* methylen blue method

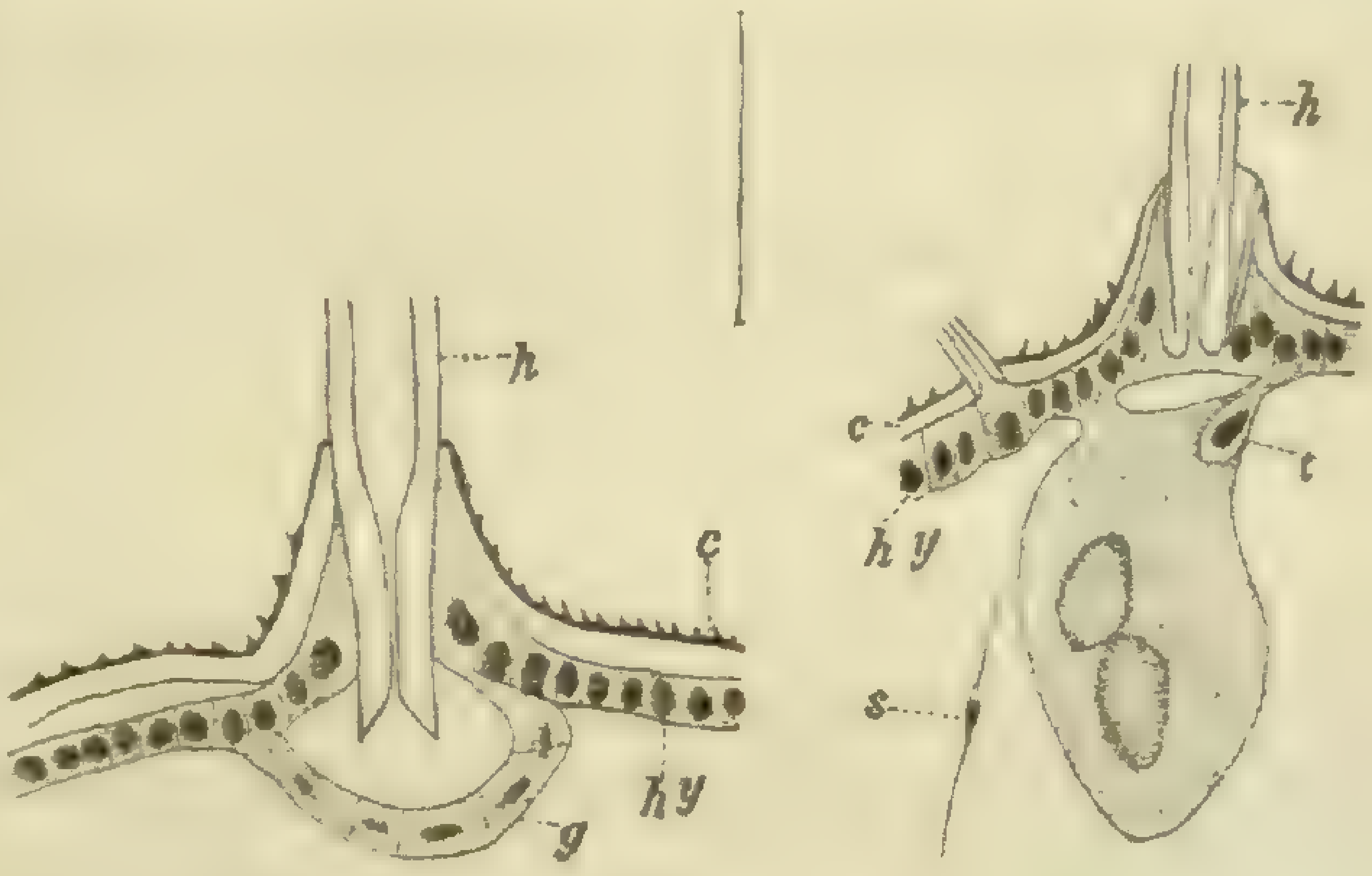

FIG. 2. — Sections through hairs from a tiger moth (*Spilosoma virginica*).

was found to be especially useful; and, as the larger part of the work was based upon results thus obtained, it may be well to give the exact method of procedure.

The fluid used for injecting was Grübler's B.x methylen blue, $\frac{1}{2}$ per cent solution in normal salt. The injection by means of a small syringe was made usually in the side, back of one of the last abdominal segments, and enough liquid was injected to color the segments near the head, care being taken to insert the canula only under the hypodermis and muscles, and not into the alimentary canal.

Fig. 3. — Section of cuticle of *Corydalis cornuta*, showing large and small flat scales supplied with nerves and cells. All beyond edge of cuticle from Golgi preparation, the sensory cells and nerves demonstrated by methylen blue.

After injection the animal was left quiet for a period of about three hours for most insects, but with some, as with Pieris, two hours was a better time, and four hours seemed to be best for Datana larvæ. It is important that the insect remain alive during this period after injection.

When the proper period has elapsed the nerves and nerve cells should be well stained and almost all other tissues free from stain. After successful staining the specimen is cut open lengthwise and pinned out over a hole cut in sheet cork, the muscles and viscera are removed by careful dissection, and then, on examining under a microscope, the nerves and nerve cells are seen stained upon the surface of the unstained hypodermal layer. The bases of the hairs may be seen through the hypodermis, and it is easy to trace nerve cells and fibers in connection with them. By keeping the preparation wet with normal salt solution and using different powers of the microscope, much may be learned regarding the structure and distribution of the peripheral nervous system without further preparation; for this work the silkworm (*Bombyx*

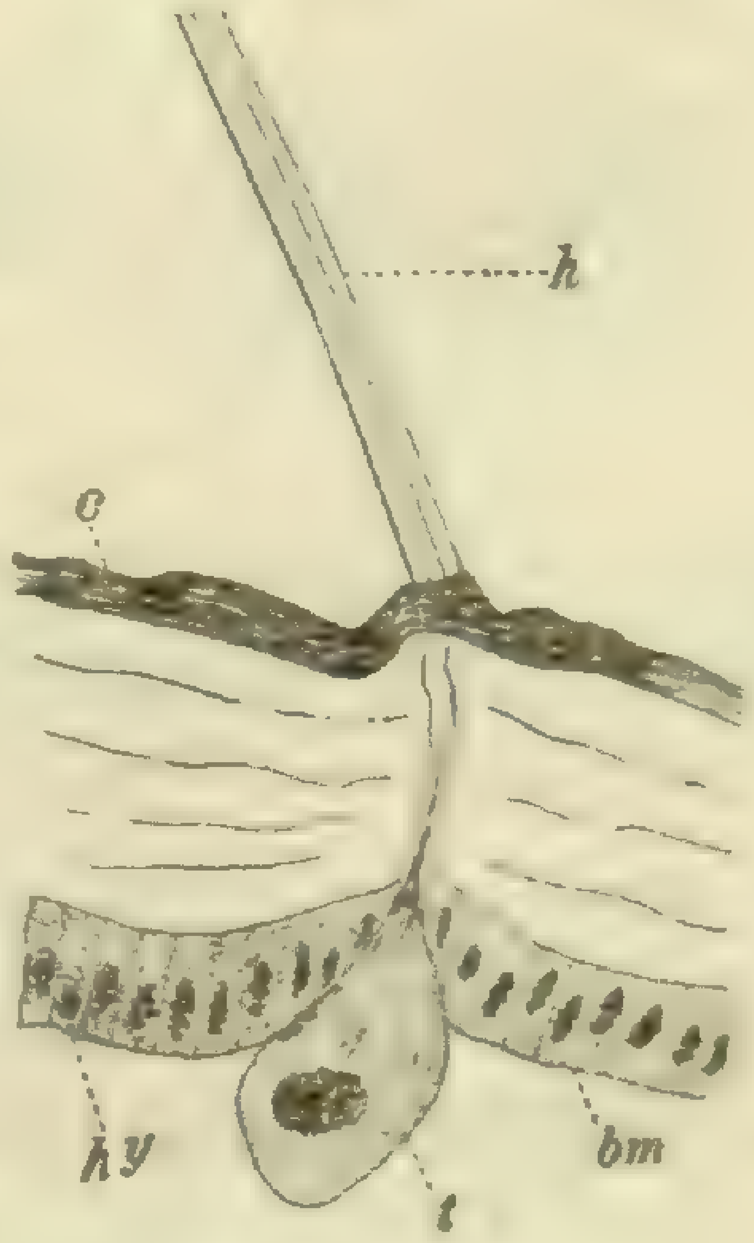

Fig. 4. — Section of hair of Datana.

mori) was very good, because the blue nerves on a pure white background stand out very clearly. Of course, such preparations last but a short time, fading out in an hour or less, and the ultimate distribution of the terminal nerve fibers cannot be seen without sectioning.

The following modification of Bethe's formula for fixation was used:

Ammonium molybdate	1 g.
Con. HCl	10 drops.
Dist. H_2O	100 cc.

This solution was used ice cold and allowed to act on the tissues from eight to twenty-four hours, after which they were washed well in cold distilled water and placed in absolute alcohol for about three hours, then cleared in xylene, and either mounted whole or imbedded and sectioned.

HISTORICAL.

Setiferous sense organs in arthropods were described by many early workers; but the first description of a bipolar nerve cell one termination of which was at the base of the hair and the other continued with the nerve trunk to the central nervous system was made by Leydig in 1851, for certain hairs of *Corethra plumicomis*. This discovery of Leydig was verified, and the form described is now generally regarded as the type of sensitive termination in arthropods. Leydig undoubtedly mistook the trichogen cells for nerve cells; these two elements were later distinguished by Hauser ('80) and Villanes ('81). Later works, especially of Retzius ('90–'95) and Vom Rath ('91–'96), brought forth the following results:

In arthropods all sensory terminations, the eyes excepted, are in hairs. To each hair there corresponds at a greater or less distance from the base one or more bipolar sense cells, of which the distal prolongation penetrates into the interior of the hair terminating without ramifying, the other prolongation (proximal) in a nervous center. These observations, which accord so well with other classic works on the peripheral nervous system, were made somewhat doubtful by more recent works.

In Crustacea, Bethe ('95) and Nusbaum ('97) recognized the sensory neuron as a bipolar cell, the distal portion penetrating the hair without ramifying and the other prolongation continuing with the nerve trunk; but, at the same time, they also described a plexus of cells, — not a system of neurons, but a true plexus. Bohumil Nemec ('96) found in certain isopods a system of peripheral ganglia. These ganglia are centers of a hypodermal plexus compared by him to the plexus of Bethe. Rina Monti ('93) described a similar plexus in insects, and Holmgren ('96) described and figured such a network of multipolar cells with their processes in the larva of a sphinx moth.

In '97 and '98 Duboscq summarized very well the results of many authors and added some of his own observations on Orthoptera and chilopods. He used both the Golgi method and methylen blue and discredits much of the former work on the nerve plexus obtained by methylen blue, and that on the termination of the nerves by the Golgi method.

Sensory Cells and Nerves of Body Sense Hairs.

Following the sensory nerve trunks peripherally, they are seen to run straight out from the central nervous system, dividing dichotomously, most of the branches coming off when the region of the back is reached. After a number of divisions, small nerves from bipolar nerve cells join the larger trunks, and the peripheral parts of the larger nerves may also be traced to bipolar nerve cells (Fig. 5).

In the silkworm (*Bombyx mori*) bipolar nerve cells are spindle-shaped and have a very dark nucleus, which in many cases nearly fills the cell body (Figs. 5–6). In most forms studied the cells are more nearly spherical, but yet not markedly so (Figs. 5–6). As a general rule the sensory cell is quite a distance from its hair, but again in the myron sphinx there is a slight variation, the nerve cell being at the edge of the pore canal, almost in its cavity; this may not indicate that the nerve is really shorter, but only apparently so, because of the thickness of the cuticle and consequent length of the pore canal.

The prolongation of the nerve just beyond the sense cell is of considerable thickness, staining deeply; and abruptly after this the nerve extending to the hair is very minute.

It was impossible to trace the nerves farther than the bases of the hairs where whole mounts were made, and Duboscq ('97 and '98), in Orthoptera and chilopods, traced the nerves only this far. However, earlier workers with methylen blue who studied simply the surface views represent nerves coming from the tips of the hairs; but it seems probable that such figures are in large part diagrammatic. Vom Rath found by the Golgi

FIG. 5.—Surface view of subhypodermal nerves and cells from the silkworm (*Bombyx mori*). Bases of hairs also shown. Methylen blue.

method cavities of sensory hairs filled with nerves; this result is regarded as an artifact by Duboscq, who shows clearly how appearances like nerves may be obtained in the cavity of hairs due to deposits of chromate of silver; and he shows quite clearly that when nothing but the nerve cell and fiber is impregnated the nerve fiber stops at the base of the hair, as was apparently the case in his methylen blue preparations.

Retzius ('95), in Astacus, by means of the methylen blue method, traced the nerve to the base of the hair. This attracted the

attention of Bethe ('96), who investigated this point and found two sorts of hairs in Astacus, one as described by Retzius, in which the cavity of the hair was shut off at its base by chitin, and the other having its cavity freely open at the base. In the closed hair a nerve fiber was seen to stop at the base of the hair, but in the open hair it was continued a short distance into the shaft, and he suggests that probably this fiber goes nearer the tip than was observed in the specimens.

It was only by means of sections that it was possible to trace the nerve in the cavity of the hair, and I found it very

FIG. 6. — The figure in the center and those at the left are surface views of subhypodermal nerves and cells from the silkworm; the bases of the hairs are also shown. The figures at the right are the same from the myron sphinx (*Ampelophaga myron*). Methylen blue.

difficult to obtain successful preparations. In the silkworm nerves were traced to the hairs by means of sections, which showed the nerves passing between the hypodermal cells, past the gland cell, or trichogen cell, without any branches, and often as far as the collar of the hair. In a few cases the nerves were traced a short distance into the shaft; but they appeared to end not far from the base of the hair on the side of the lumen (Fig. 7). Either in the hair or just below it a rather large

swelling of the nerve was usually seen; this is possibly an artifact. In a few cases nerves were traced perhaps one-half the length of the cavity. In these cases there was a swelling of the nerve just before its apparent termination (Fig. 7).

I found no evidence to indicate nerves ending in gland cells or trichogen cells by such branches as have been described and figured by Blanc ('90), but in every case the very fine nerve termination could be traced up past the hypodermal cell layer with no branches.

SUBHYPODERMAL NERVE PLEXUS.

Villanes ('81), in insects, figures a subhypodermal nerve plexus made up of multipolar nerve cells. In '93 Rina Monti, also working on insects, described a similar plexus, and in '95 Bethe described similar structures in Crustacea. Nemec ('96), in isopods, and Holmgren ('96), in a sphinx-moth larva, show multipolar networks of subhypodermal cells. All the work thus far was by means of methylen blue or ordinary methods, and because of the apparent antagonism with the neuron theory much attention was directed to this subepithelial plexus, and doubts were raised as to the nervous nature of these cells. In 1898 Schreiber, who had already in 1897 together with Nusbaum published a paper on the peripheral nervous system of Crustacea showing these multipolar cell plexuses, published another short paper showing these cells demonstrated by means of a modified Golgi method, and at the close of his article draws the following conclusions:

1. An identical methylen blue staining of the subepithelial multi- and bi-polar nerve cells.
2. Like staining of both forms of cells by the Golgi method.
3. True connections of the nerve cells with nerves.

A few months later Holmgren confirms, on the whole, Schreiber's results, but speaks of many-branched subhypodermal cells, as described by Bethe in Crustacea, and probably confused by Nusbaum, Schreiber, and other writers on Crustacea with multipolar nerve cells. Holmgren distinguishes

these cells from the true multipolar nerve cells of Crustacea, regarding them as many-branched mesenchymatous cells. In lepidopterous larvæ Holmgren states that there are no mesenchymatous cells like those in Crustacea which one would confuse with nerve cells.

In 1897 and 1898 Duboscq criticises the work of many previous workers upon multipolar subhypodermal nerve cells and states as his opinion that the bipolar nerve cell is the only true nerve cell in the hypodermis of arthropods, and that there is no subepithelial plexus. Although much of the criticism of a subepithelial plexus by Duboscq is very just, it seems to me that simply calling all such structures so described connective

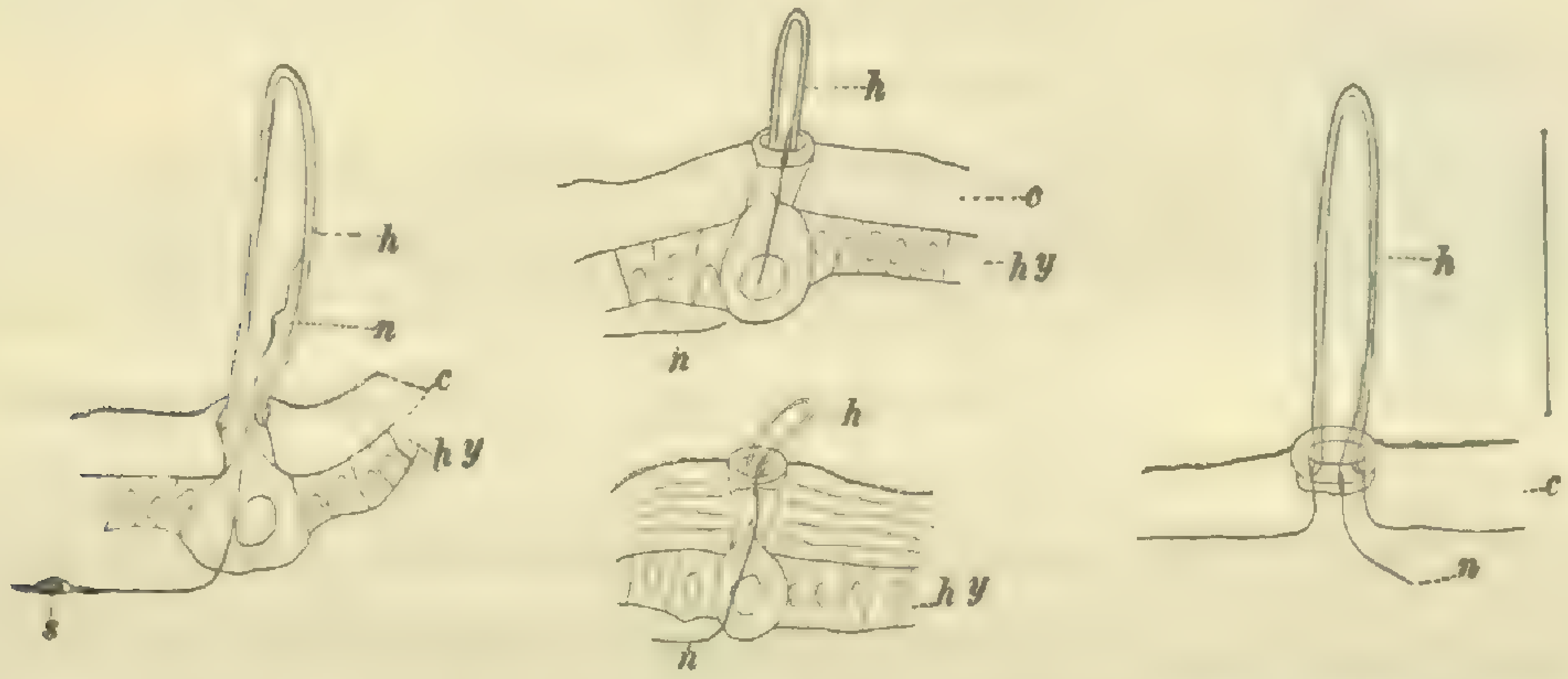

Fig. 7.— Sections through body sense hairs of the silkworm showing the nerve terminations. Methylen blue.

tissue is hardly justified when we look over the works of numerous observers. It may in part be true, as Holmgren points out, that much which has been described, especially in Crustacea, may come under the head of mesenchyma, but do we not have multipolar nerve cells as well?

The occurrence of evidently multipolar nerve cells together with bipolar nerve cells and fibers I found to be very constant in lepidopterous larvæ (Fig. 6). The nucleus of these multipolar cells was a very well marked, clear area occupying a large part of the center of the cell; in the center of this clear area was a darker staining portion, possibly the nucleolus. These cells with their many fine branches always take a paler blue stain than the other nervous structures in the skin. The very fine branches of these multipolar cells run out long

distances, and in the most successful preparations may be seen to join with similar branches from other multipolar cells and with other nerves. In some cases, as shown in Figs. 5–6, branches from these went directly to bipolar nerve cells or to large nerve trunks. These cells are always either in series with at least one bipolar nerve cell (Fig. 6) or have some of their branches joining the nerve trunk of the bipolar cell, or they are not far from one of these sensory cells. Often it was seen that these cells occupied a position closer to the hypodermal cells than other nervous tissues, and sometimes large nerve trunks would end bluntly, and under the ends of such trunks would be found a multipolar cell, perhaps giving one of its branches to a bipolar nerve cell (Fig. 6).

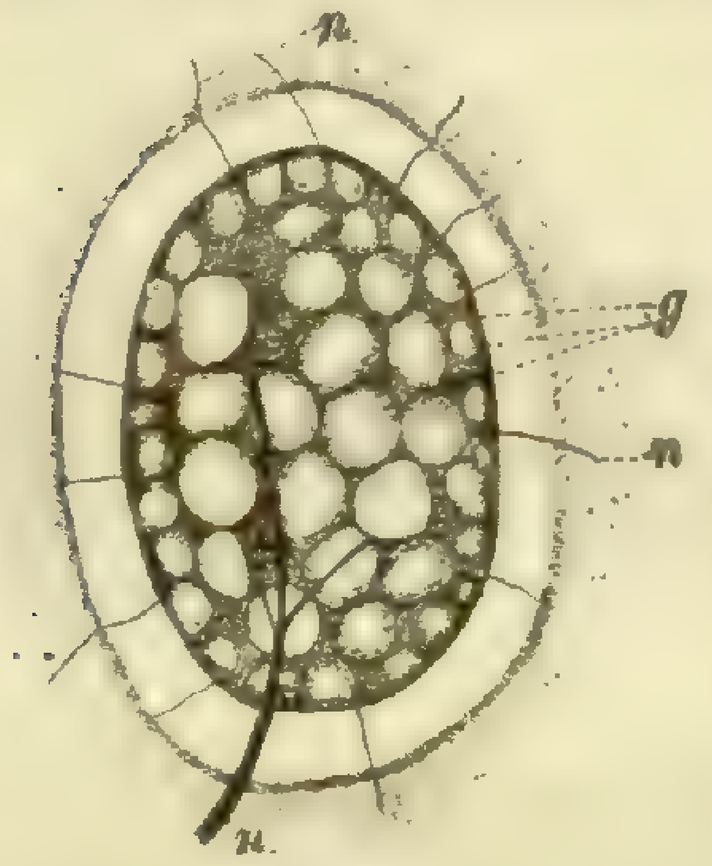

FIG. 8. — Inner face of body wall of tiger-moth larva tubercle, showing nerves going up into the elevation and breaking up among the large cells at the bases of the hairs. (× 22.) Methylen blue.

These cells were best observed in the silkworm and in the myron sphinx larva, but they were also seen in Pieris, Datana, Papilio, and practically in all forms studied. Whether these multipolar cells are nervous tissue or not cannot be fully decided as yet, but although they differ somewhat in position and staining qualities from other undoubted nerve cells, they have many characteristics which favor their being regarded as nervous tissue.

Aside from a network of multipolar cells with their processes another sort of plexus was observed. In tiger-moth larvæ the hairs are on little knoblike elevations. After injection and staining of nerve fibers there are found to go to each of these hair tubercles a large nerve, which, after entering the elevation, may be seen to break up into branches (Fig. 8), and in sections it may be seen that these branches break up still finer and each subdivision goes to a bipolar cell connected with a hair. Now, besides these larger nerve trunks, smaller ones are also seen entering the elevations, and often in successful preparations near the edge of the hair tubercles there may be seen a very complex network of apparent nerve fibers with many swellings, as shown, much enlarged, in Fig. 9. This network

is apparently entirely without cellular elements and is at the same time a part of the nervous system. These networks in tiger-moth larvæ were only observed near the hair tubercles; in the silkworm a much less marked network of large and small fibers was occasionally found.

It is hard to say whether this network is truly a part of the nervous system or not; but in any case these networks are

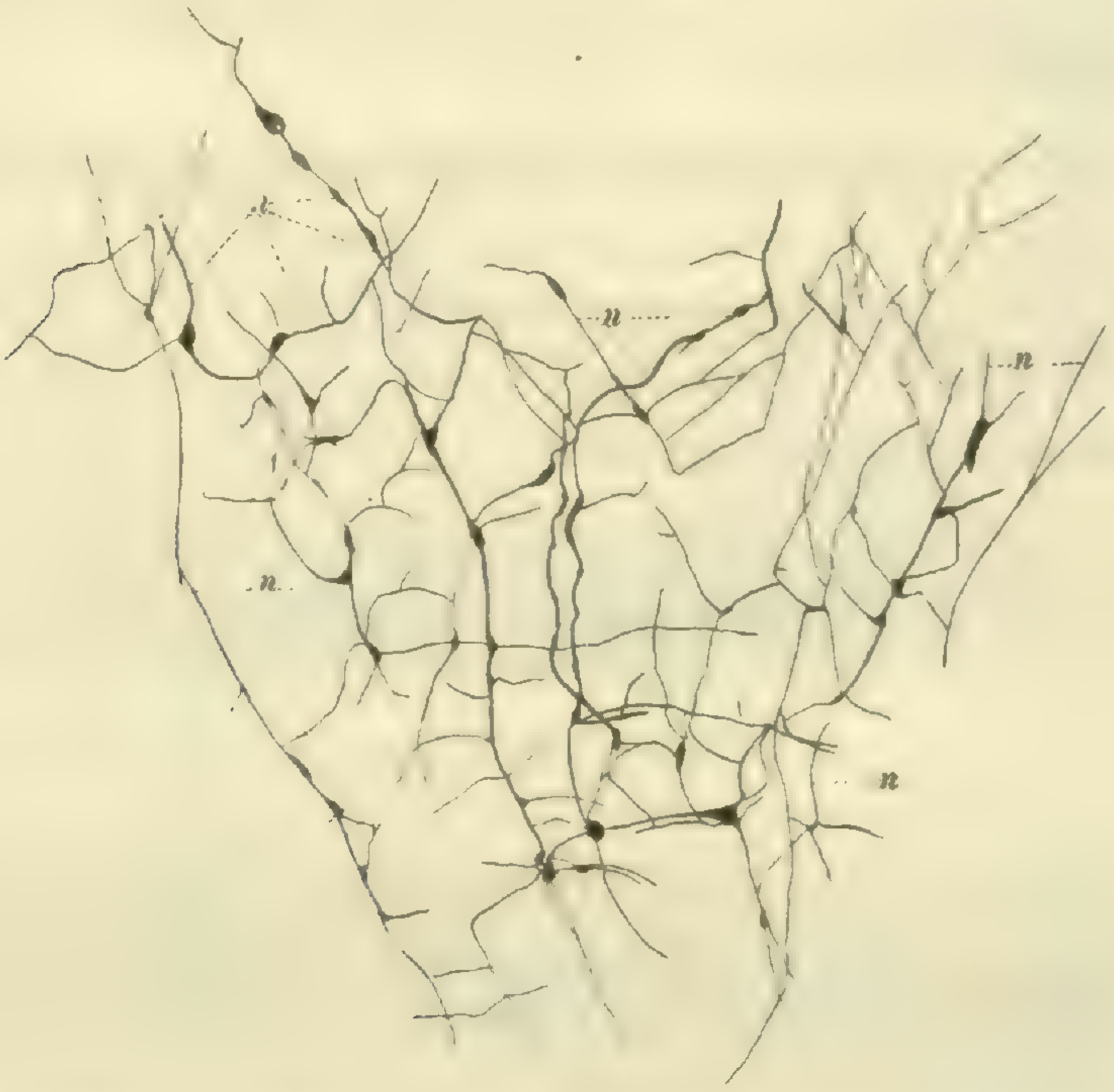

Fig. 9. — Nerve plexus from edge of hair tubercle of tiger-moth larva, much enlarged. Methylen blue.

not at all like the multipolar cells just described, no nuclei or cells being recognized, but they are well stained with methylen blue and join undoubted nerves.

Central Ending of Sensory Nerves.

It was not the purpose of this investigation to make a study of the central nervous system, but as it became necessary to trace the nerve fibers to the ganglia, several interesting conditions were noticed which have a more or less direct bearing upon the previous work; a few of these will be spoken of, although it is realized that no complete discussion can be given without considerable further study, and consequently further

investigations will probably bring out more complex relations than here portrayed.

On each side of the abdominal ganglia of Pieris there are two large branches or nerve trunks (Fig. 10). The more cephalic of these comes from bipolar nerve cells at the bases of hairs, and the other more caudal branch goes to muscles; so, as nearly as could be determined, the cephalic trunks are sensory and the caudal ones motor. There may have been a few motor nerves in the cephalic trunk and sensory nerves in the caudal one, but if there were such, they were inconspicuous and not noted in the examination of numerous specimens; so for the present, at least, the more cephalic branch may be regarded as a sensory branch.

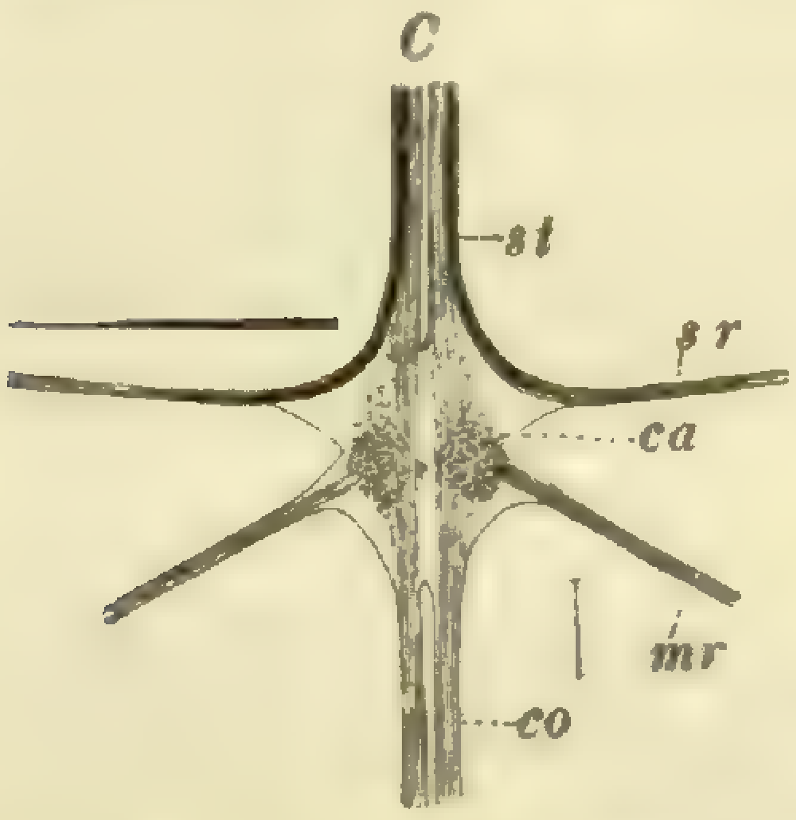

FIG. 10. — Abdominal ganglion from Pieris. Methylen blue.

This sensory branch upon entering the ganglion seems to run as a distinct tract cephalad without sending branches to the central cell area of the ganglion. This tract runs cephalad for some distance along the outside of the connective and is finally lost sight of. The course of the motor nerve is quite different; its fibers seem to come directly from the central cell area of either side of the ganglion. Aside from the fibers just described, there are nerve fibers which may be seen to run through the ganglion longitudinally; these take a lighter stain. They run along the connectives and are just inside the sensory tracts.

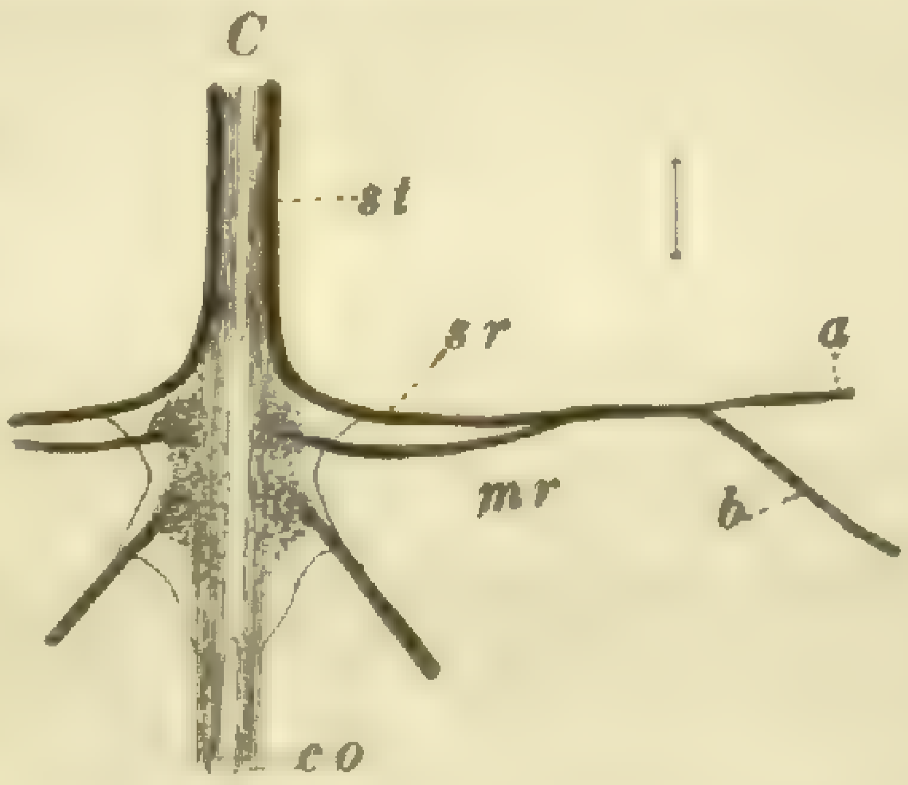

FIG. 11. — Abdominal ganglion from Io caterpillar (*Automeris io*). *a*, from hairs; *b*, to muscles.

Variations in the number and position of the nerve trunks from the ganglion occur in different species. In Io and in a tiger moth the same sensory tract may be noted, but part of the sensory trunk upon entering the ganglion leaves the sensory tract and enters the cell area (Fig. 11), but on

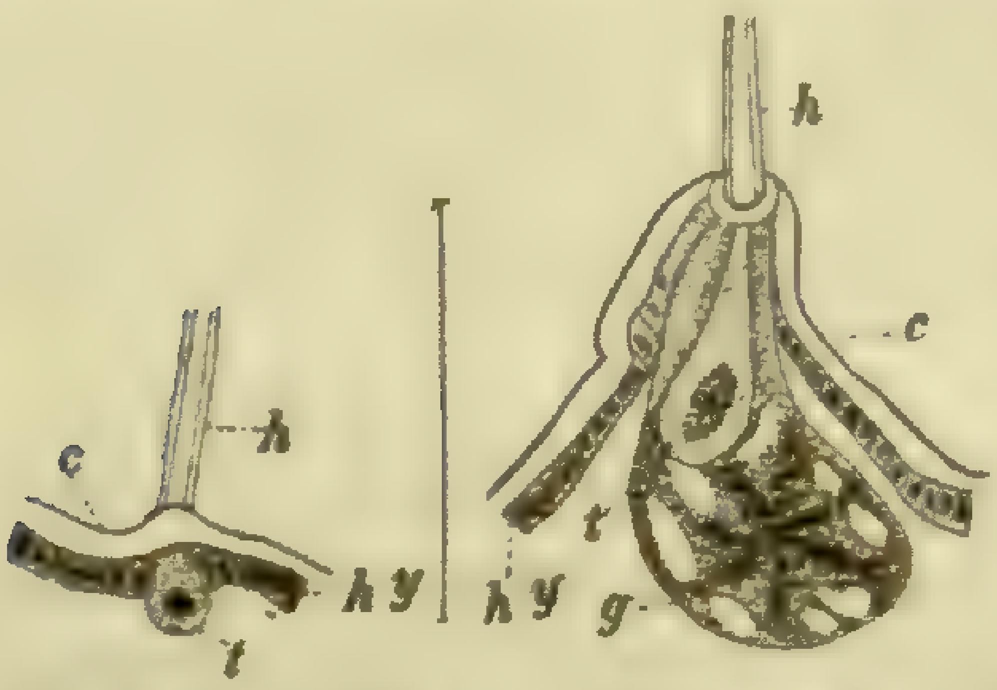

FIG. 12. — Small and large hairs from *Pieris rapæ*.

tracing the nerve to the periphery it is found that part of the fibers of the more cephalic nerve come from the muscles, and so the nerve may be regarded as a mixed nerve, showing why some of its fibers do not follow the sensory tract.

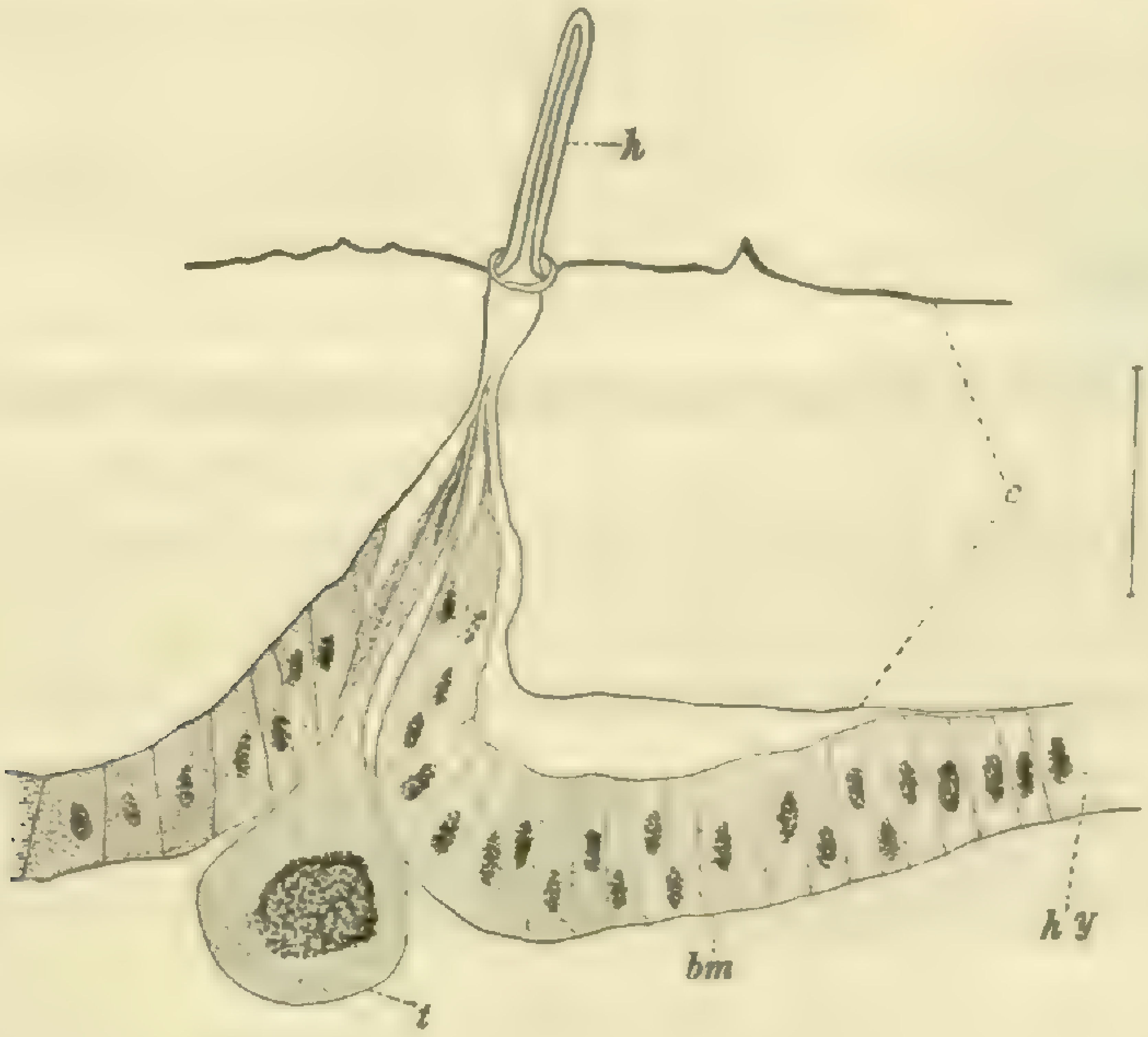

FIG. 13. — Section of hair from *Sphinx chersis*.

In lepidopterous larvæ the two sides of the ganglia seemed to be separate, possibly because of imperfect methylen blue stain. In Coryalis larva fibers were seen to cross from side to side.

GENERAL RESULTS.

In the lepidopterous larvæ examined two kinds of body sense hairs were found: first, *simple hairs*, those having a single enlarged hypodermal cell at the base (Fig. 12); and, second, *glandular hairs*, or those having two rather large modified hypodermal cells (Fig. 12). In the latter case the smaller cell is probably the trichogen cell, and the other a glandular cell of some sort. As these figures were drawn from specimens prepared in the ordinary way, the nerves are not shown.

Examples of simple hairs are represented by Figs. 13–18. The insects from which these figures were drawn are indicated in the explanations of the plates. Glandular hairs are represented by Figs. 12 and 19.

In all species examined both simple hairs and glandular hairs were found to be supplied with a bipolar sensory nerve cell and fiber. Sometimes, as in Pieris and Datana, there are two quite distinct kinds of hairs, large and small. In this case the large hairs are supplied by large bipolar nerve cells, and the small hairs by small ones (Fig. 20).

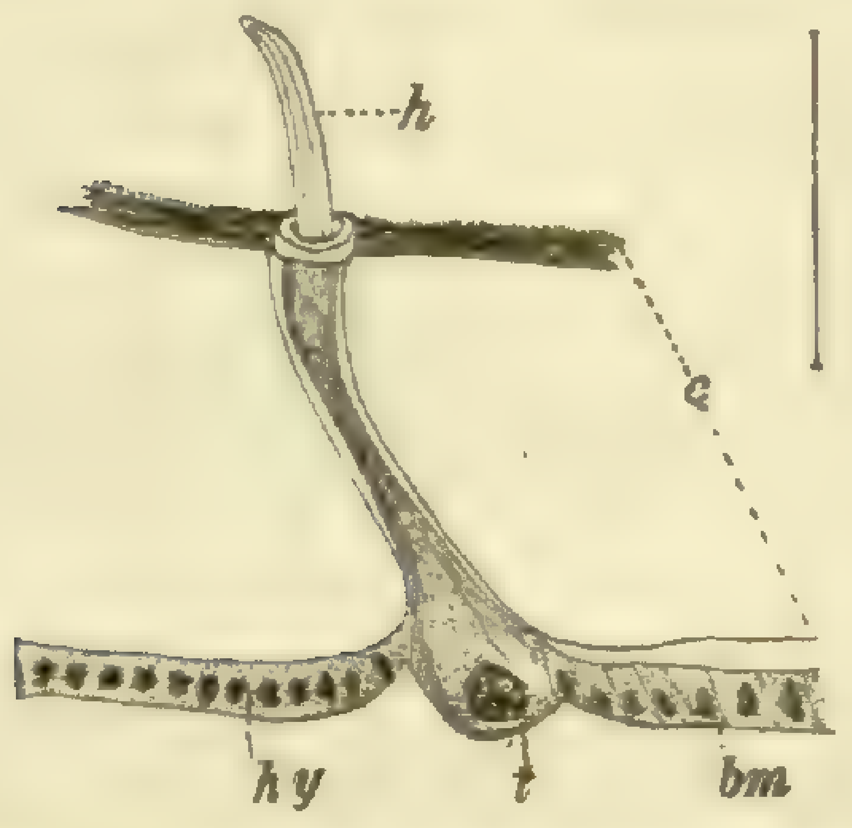

FIG. 14. — Section of hair from body surface of *Thyreus abboti*.

In tiger moths and tussock moths the hairs differ somewhat from those in other forms; here the single hairs of other lepidopterous larvæ are represented by bunches of hairs clustered together on tubercles. Each tubercle is supplied by one or more large nerve trunks, which break up on entering the tubercle. A bipolar nerve cell from each hair in this case is harder to determine absolutely; but as some of the hairs were found to have such nervation, probably all do, for all are of the same kind. The structure of these hairs differs somewhat from those already described in the form and shape of the cells, these sometimes being hollow or saclike with radiating nuclei (Fig. 2). The base of the hairs also presents variations, as shown in Fig. 2; here the chitinous base of the hair seems to extend down below the level of the cuticle. In a section through the base of a hair of Notolophus (Fig. 21) the opening of the hair is seen to be nearly closed in two places by strong processes of chitin, and sections taken just one side of the middle line show apparently a closed hair, indicating how small the opening is in the base of the hair.

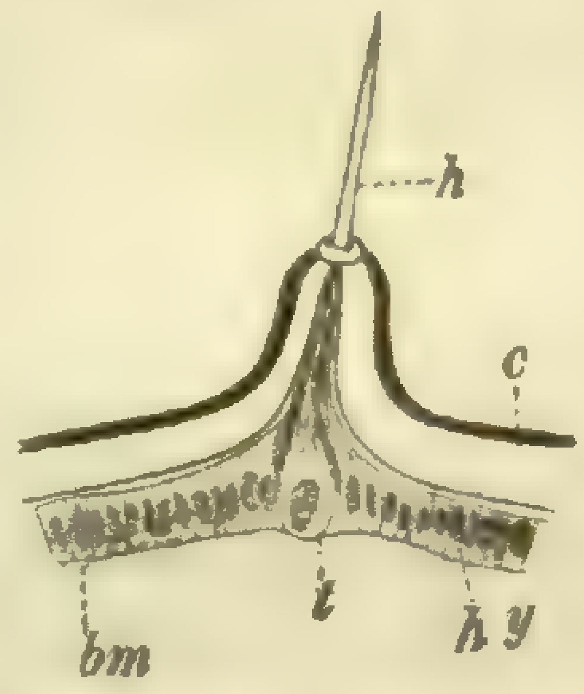

FIG. 15. — Section of hair of *Basilarchia archippus*.

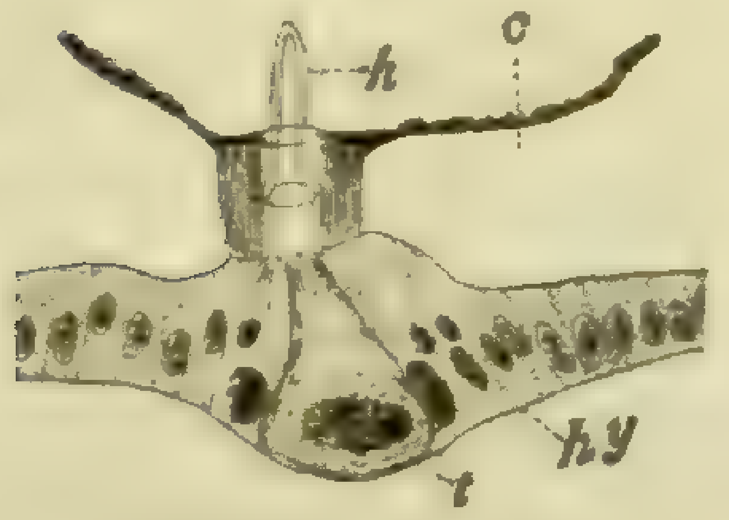

FIG. 16. — Hair from *Samia cecropia*.

All the hairs examined in lepidopterous larvæ were open and undoubtedly sensory, that is, supplied with bipolar sense cells.

Differing from the hairs just described, there are distributed over the surface of the body of the larva of the Io moth spine-like clusters, prolongations of the body wall (Fig. 22); most of these spines are tipped with short, strong, chitinized caps, and a few with long, slender, hairlike processes. These spines when touched to the tender surface of the hands produce swellings which are slightly painful. Numerous specimens stained by methylen blue demonstrated fine nerves running into these spinous processes and extending almost to the tips, but no bipolar nerve cells were demonstrated. Evidently here we have glandular hairs, but not sensory hairs; however, in the same specimens there were found hairs of the usual type, much smaller than these processes of the body wall or spines; these true hairs were located both on the bases of the spines and upon the body wall between the spine clusters (Fig. 22, *h*). No difficulty was experienced in demonstrating a bipolar nerve cell at the base of each of these true hairs.

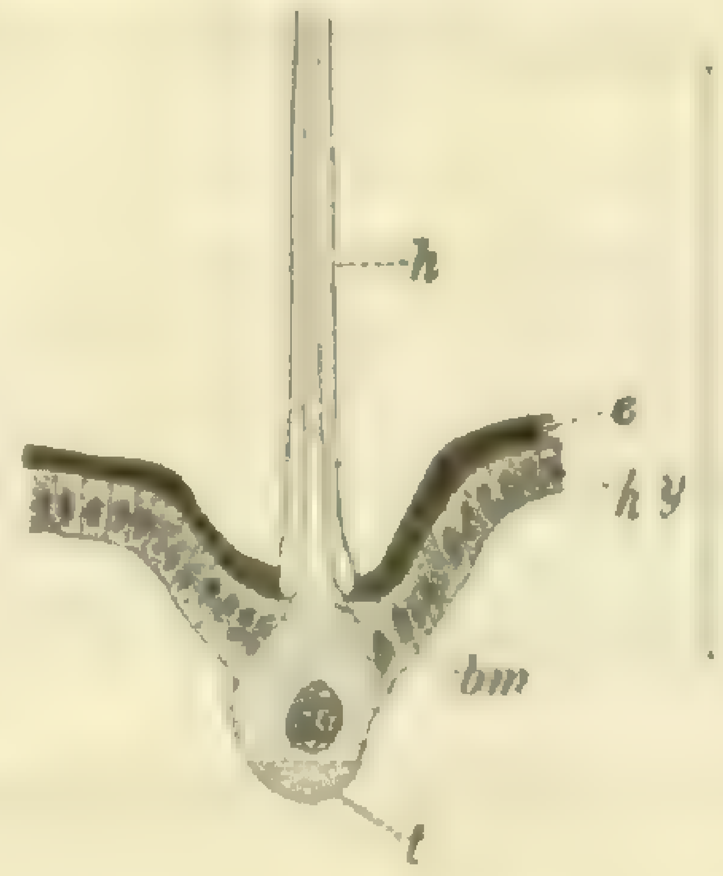

Fig. 17. — Simple hair from *Chisio-campa americana.*

Fig. 18. — Silver-spotted skipper (*Epargyreus tityrus*).

To summarize briefly: all lepidopterous larvæ studied have their bodies clothed with hairs, and all the hairs are sensory, having a bipolar nerve cell at their base and supplied with a minute nerve fiber, with the possible exception of the poison spines of Io caterpillars.

To carry the generalizations a little further, the following observations are useful. In the larvæ of May beetles the hairs of the body surface are supplied with bipolar nerve cells (Fig. 23), and in Orthoptera, as already spoken of by Duboscq ('97), the hairs have a bipolar sense cell at their base. In the larva of Corydalis, bipolar nerve cells with their fibers supply each of

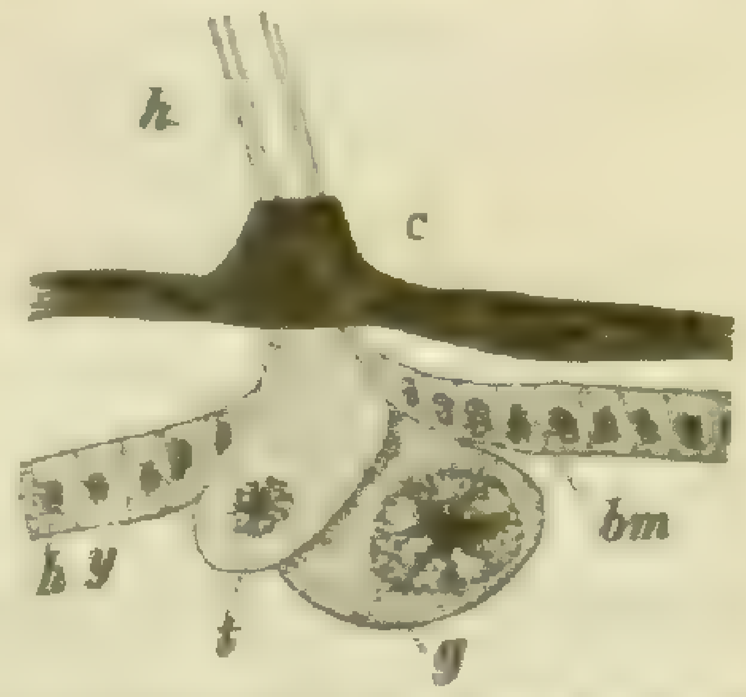

Fig. 19. — Large, probably glandular hair from Chisiocampa

the numerous little, black, scalelike hairs which so thickly cover the body ; large hairs have larger bipolar nerve cells (Fig. 3).

Günther ('01) shows scales of a lepidopterous wing with nerve cells at the base of both simple and glandular scales, probably a similar result to that just described in Corydalis.

FIG. 20.

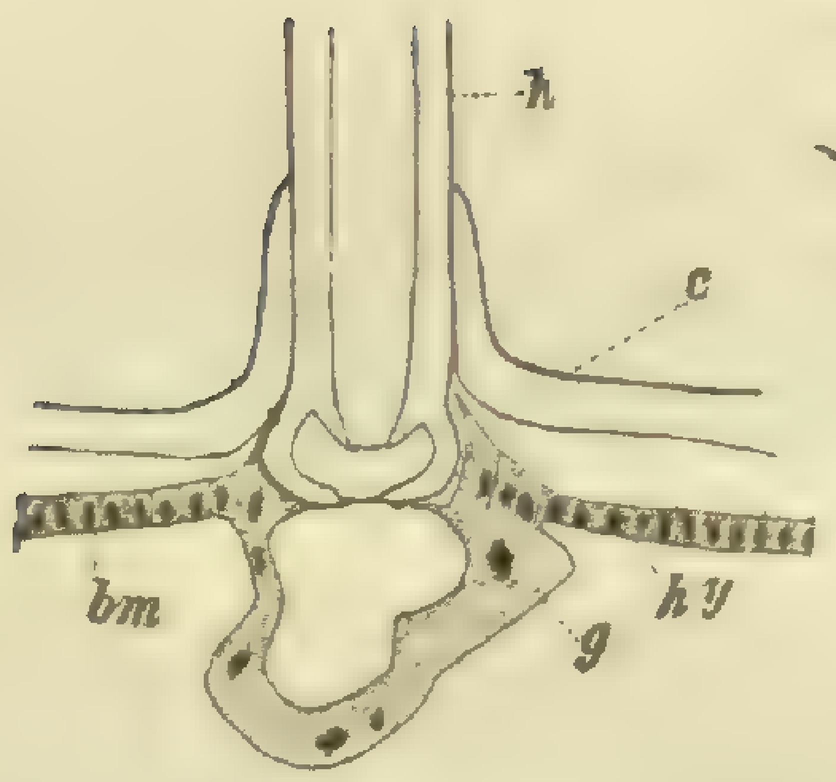

FIG. 21.

FIG. 22.

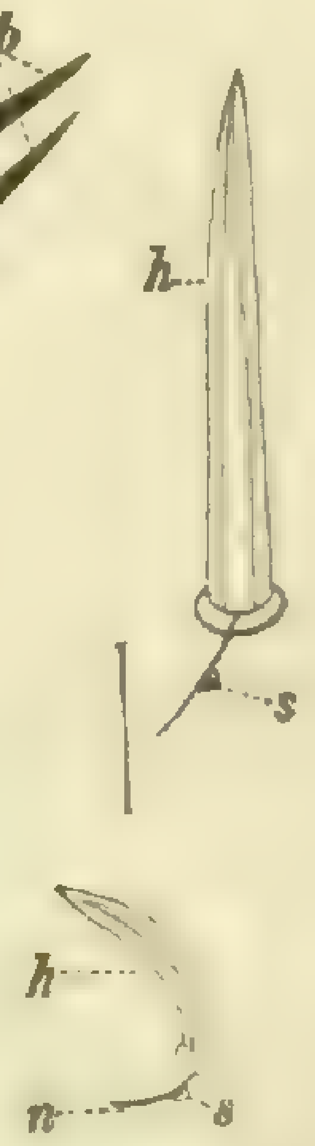

FIG. 23.

FIG. 20. — Bases of large and small hairs from Datana, showing their bipolar nerve cells. Methylen blue.

FIG. 21. — Section through center of hair of *Notolophus leucostigma*.

FIG. 22. — Cluster of spines from Io. (× 17.) Methylen blue. *a*, hairlike spine ; *b*, usual type of spine.

FIG. 23. — Large and small hairs from beetle larva with their sense cells and nerves. Methylen blue.

SUMMARY.

1. Lepidopterous larvæ are clothed with hollow hairs, each of which is supplied by a bipolar nerve cell, a process of which penetrates a short distance into the hair and probably terminates before reaching the tip.

2. In most species all body hairs are sensory ; large hairs are supplied by large bipolar nerve cells, and small ones by smaller bipolar cells.

3. Under the hypodermis of caterpillars there is a system of multipolar cells more or less intimately connected with nerve

cells and fibers which (*a*) stain lighter than the larger nerves and (*b*) are closer to the hypodermis than the other cells and fibers.

4. Nerves from bipolar sensory nerve cells go to the central nervous system, run to the ganglia, leaving at once to follow on the outside of the connectives cephalad, forming a well-marked sensory tract. Motor nerves — those that go to muscles — seem to come directly from the central cell areas of the ganglia.

5. Almost the only sensory termination of nerves on the body of insects is by means of hairs.

I wish to make my very sincere acknowledgments to Professor Comstock and the Department of Entomology for much invaluable aid in the preparation of this paper.

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'94 RATH, O. VOM. Ueber die Nervenendigungen der Hautsinnesorgane der Arthropoden nach Behandlung mit der Methylenblau und Cromsilbermethode. *Berichte der natur. Gesellsch. zu Freiburg.* 1894.

'96 RATH, O. VOM. Zur Kenntniss der Hautsinnesorgane des sensiblen Nervensystems der Arthropoden. *Zeitschr. f. wiss. Zool.* 1896.

'90 RETZIUS, G. Zur Kenntniss des Nervensystems der Crustaceen. *Biol. Unt.* N.F. 1896.

'92 RETZIUS, G. Ueber die Nerven-Prinzipien in der Lehre von der Einrichtung des sensiblen Nervensystems. *Biol. Unt.* N.F. 1892.

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'98 SCHREIBER, W. Noch ein Wort über das peripherische sensible Nervensystem bei den Crustaceen. *Anat. Anz.* 1898.

'81 VILLANES. Sur les terminations nerveuses sensitives dans la peau de quelques insects. *C. R. Acad. Sc.*

'83 VILLANES. Recherches sur l'histologie des insects et sur les phénomènes histologiques qui accompagnent le développement postembryonnaire de ces animaux. *Th. Pairs.* 1883.

ABREVIATIONS USED IN FIGURES.

bm = basement membrane.
C = cephalic direction.
c = cuticle and cuticular thickenings.
ca = central cell area.
g = gland cell.
h = hair.
hy = hypodermis.
mr = motor root.
s = sensory cell.
st = sensory tract.
co = connective.
m = multipolar cell.
n = nerve.
sr = sensory root.
t = trichogen cell.

Lines near drawings indicate $\frac{1}{10}$ mm.

HISTOLOGICAL CHANGES IN HYDRA VIRIDIS DURING REGENERATION.

HANNAH TERESA ROWLEY.

ALTHOUGH a great deal of work has been done on the regeneration of hydra, no one has as yet attempted to make out the histological changes that take place. This point would seem to be one of special interest, since the old piece appears to change its form as a whole to produce a new animal. The principal question to which I wished to find an answer was whether, during the period of regeneration, the old cells go over without change into the tissue of the new animal, or whether new cells are formed, and if so, in what part or parts.

Green hydras were used almost exclusively, since they regenerate more readily and with fewer abnormalities than does the brown species. Hydras of various lengths were taken, the foot end and circle of tentacles were cut away, and the remaining middle parts of the body wall were each divided by cross cuts into four — in some cases two — small rings. These were allowed to regenerate, and at different periods, ranging from immediately after the cutting to some days after the formation of new tentacles and foot, were killed in a solution of corrosive acetic, hardened, sectioned lengthwise, and stained in Delafield hæmatoxylin. In some cases the slides were dipped for a moment into a weak solution of picric acid in absolute alcohol, in order to differentiate the endodermal tissue.

Observation of the living piece showed that the ends became rounded, closing in from fifteen to sixty minutes after having been cut; that the piece then remained without permanent change of form for thirty or forty hours, although at intervals it might change its shape by expanding and contracting. At about this time small knoblike outgrowths, the tentacles, began to appear at one end, the other end fixed itself to the nearest

support, and in a few days the proportions of a normal hydra were assumed.

Serious difficulties arose in the microscopic study of the prepared sections, which it may be well to mention. Although undoubted karyokinetic divisions were seen in both neuro-muscular and interstitial cells of the ectoderm, and in the endoderm, it was found almost impossible to determine the exact amount of dividing tissue, for the following reasons.

Throughout the entire period of regeneration there is an active production of new nettle cells, which are formed from interstitial cells of the ectoderm. This process begins by a slight sickle- or moon-shaped thickening of protoplasm along a part of the cell wall. In certain sections this thickening appears as a small, darkly stained rod which may easily be mistaken for a small nucleus in process of division. Again, in sectioning, this curved, thickened rod may be cut at such an angle as to bring distinctly into view only its extremities, producing the appearance of two small groups of darkly stained material. These could be distinguished from two separating groups of chromosomes only by bringing into focus the connecting line of the rod, which would lie slightly above or below the ends. In many cases it was found almost impossible to determine whether such a cell was forming a cnidocyst or was dividing karyokinetically. These difficulties were increased by the small size of many of the interstitial cells, by the fact that the wall of such cells is not sharply defined, and by the fact that at the time of the formation of nettle cells it is very often difficult to make out the nuclei of the changing cells.

Moreover, many nuclei of both neuro-muscular and interstitial cells were found to be in a state that distinctly suggested activity of some sort, — the chromatin mass large and loose, or even in many interstitial cells broken and scattered throughout the nucleus. This appearance was very different from that of nuclei of typical resting cells in the same section, the latter containing one or two well-defined nucleoli. Yet the large number of nuclei with the chromatin scattered as just described, in sections containing comparatively few karyokinetic spindles, would seem to indicate that all such cells were not necessarily

dividing. Where so many cells were about to divide or had just completed division, we should expect to find a corresponding number undergoing the actual process. This, however, was not the case.

A further point should also be kept in mind, *viz.*, the possibility that multiplication of the interstitial cells may be concerned with the development of new nematocyst cells rather than with the regeneration of new tissue.

In order to get more light on these points, the tissue of a normal hydra was examined for comparison with that of the regenerating piece. Another hydra was irritated with a blunt needle in order to induce it to discharge the nettle batteries. It was then left undisturbed for about twenty hours, at which time it was killed and the tissue prepared as has been described. It was hoped by these means to obtain further light on the difficulties of the question, and to be able to distinguish more clearly between the phenomena of regeneration and those merely incidental to the formation of new nettle cells.

In the case of the stimulated hydra, nettle cells were found to be forming as in the regenerating pieces. Moreover, in the tissue of this hydra and of the undisturbed normal one also I was surprised to find undoubted evidence of cell division, in addition to the very general loose and broken appearance of the chromatin in some of the interstitial cells, which has been noted as occurring in the regenerating piece. This latter condition, found in a hydra upon which no operation had been performed, made it still less possible to consider such nuclei as dividing. On the other hand, a piece that had been regenerating seven days, and that had attained to the proportions of a normal polyp, was found to present the same appearance under the microscope. It is possible, therefore, that the normal tissue examined was that of a growing hydra, and that these conditions are common to the regenerating and growing forms, while further examination of the tissue of fully grown hydras might show a somewhat different state.

While these latter experiments, therefore, threw little light on the amount of division in the regenerating piece, yet the similarity in appearance between this regenerating tissue, the

tissue of the regenerating piece after the normal form had been attained, and the tissue of normal or growing hydra is of importance in a consideration of regeneration in this form.

I shall now attempt to make a conservative statement of the amount of dividing tissue in regenerating hydra, based on undoubted cell division.

There is very little evidence of the formation of new tissue during the early stages; an exception was noted in one piece killed five hours after the cutting, in which a number of divisions were observed in the ectoderm. Some few divisions can be observed before twenty hours, but from forty hours on, — the time of tentacle formation, — the division is more active and the number of dividing cells, especially neuro-muscular cells, is considerable. Division continues after the tentacles have begun. Spindles were seen in endodermal cells, and in neuro-muscular and interstitial cells. These divisions often occur in groups, especially in the neuro-muscular cells. In one case as many as five dividing nuclei of neuro-muscular cells were observed at one spot in a section cut from the side of the piece and so affording a surface view of ectoderm tissue alone. Fewer divisions were seen in the endoderm than in the ectoderm, partly, perhaps, because of the smaller number of cells in the endoderm.

Unlike the majority of cases of regeneration, however, the new cells are not formed at the cut surface alone, and the tentacles do not seem to be regenerated solely from new tissue. Divisions were found to occur as well at the sides as at the ends of the regenerating pieces, and in almost, if not quite, as great number. The first appearance of the tentacle, which in the living animal seems to be brought about by an outpushing of the tissue of the original piece, appeared under the microscope to be due very often to contraction in this region, causing a very slight protuberance of ectoderm, which could be fully accounted for by an outpushing of old material without the formation of new tissue. Divisions were sometimes seen at this place, sometimes not. Very frequently, however, in later stages, when the tentacle had grown to some length, there was seen to be a group of neuro-muscular cells dividing

at the base of the tentacle, and interstitial cells were seen to be dividing quite rapidly in the tentacle itself. It would seem, on the whole, that new tissue is furnished to the tentacle by division of cells at the proximal end, or base, rather than by division of cells that have already entered into the new organ.

With the exception of the formation of nettle cells from interstitial cells, it is not found that cells of one kind give rise to cells of another, but that neuro-muscular cells of the new hydra result from neuro-muscular cells of the piece, and interstitial from interstitial.

Considering, therefore, that the first appearance of the tentacle may be unaccompanied by cell division in its immediate neighborhood ; that cell division, though frequently found in the region of the growing tentacle, is not confined to this region but is found elsewhere throughout the length of the regenerating piece ; that division is found to be present as late as seven days after the cutting, that is, after the piece has assumed the proportions of a normal hydra ; and that some division is observed in the tissue of the normal, probably rapidly growing hydra, — we are justified, I think, in concluding that the new cells which appear during the regeneration of hydra are formed by division of the old cells throughout the entire piece, as in the normally growing animal, and that the tentacles are formed from old cells and from cells that have arisen by division of the already differentiated cells of the old part.

I am very much indebted to Prof. T. H. Morgan, under whose direction this work was carried on.

Bryn Mawr, January, 1902.

NOTES AND LITERATURE.

ZOÖLOGY.

The Fishes of Guam. — In the director's report of the Bernice Pauahi Bishop Museum at Honolulu (for 1900), Mr. Alvin Seale, curator of fishes, gives a record of the birds and fishes collected by him on the island of Guam. Two hundred and seventy-four species of fishes were obtained, of which eighteen are described as new, useful descriptions being given of all the others. The fauna differs considerably from that of Hawaii, the number of species common to the two groups of islands being less than one-third of the number enumerated. The fauna of Guam naturally approaches more nearly to that of the East Indies. In commenting on this most valuable and helpful piece of work, the first accurate faunal list of fishes of Polynesia yet published, two minor criticisms are necessary.

The proof reading should receive more careful attention; Zebrasoma appears three times as Zabrasoma, and *Garres argyeus* stands for *Gerres argyreus*. Still more important is the form given to new names. *Pseudoscarus platodoni* apparently refers to the broad teeth (platyodon or platyodus). *Percis cephalopunctatus* is unfortunately named and is, of course, not an agonoid, but a species of Parapercis, a genus of trachinoid affinities. *Gobius deltoides* belongs to some genus other than Gobius. These and other corrections will doubtless be made in due time by the author, and the work will prove most useful to future students of the Polynesian fish fauna. D. S. J.

Notes on Fishes. — Henry W. Fowler notes in the *Proceedings of the Academy* at Philadelphia (Vol. LIII, Pt. III) the occurrence of *Myctophum phengodes*, collected off the west coast of Greenland by Dr. Hayes.

In the *Zoologischer Anzeiger* (Bd. XXV, No. 666) Dr. Poche calls attention to the identity of the three nominal genera of siluroid fishes, called Amphilius, Anoplopterus, and Chimarrhoglanis, the name Amphilius being the earliest.

In the records of the Australian Museum, Edgar L. Waite records numerous fishes from western Australia, with valuable notes and

several plates. In another article he gives useful notes on an Australian shark, Galeus, or *Mustelus antarcticus*, and its peculiar placenta-like structure attached to its young.

In the *Zoologischer Anzeiger* for Nov. 25, 1901, Dr. K. Kishínouye, head of the Fisheries Bureau of Japan, describes a new shark, *Rhinodon pentalineatus*, taken off Cape Inubo in Japan. This huge animal is over thirty feet in length, and had an oak stick a foot long in its stomach. The stuffed skin is preserved in Tokyo.

A skin of the whale shark called *Rhinodon typicus* has just been received at the United States National Museum from Ormond, Fla. The skin is eighteen feet long. The species is known thus far from the type from the Cape of Good Hope and from teeth taken at the Seychelles Islands. Mr. B. A. Bean notes this discovery in *Science*.

In the *Bullétin de la Société Philomathique* (N.S., Tome III, Nos. 3, 4) Dr. Pellegrin discusses those fishes which develop with age an adipose pad on the forehead. This is found in numerous wrasse-fishes, parrot fishes, snappers, and others. These appendages are chiefly confined to adult male fishes and are made of adipose tissue. Pellegrin compares it to the deposit of fat in old age in some human individuals.

In the *Overland Monthly* for February and March Mr. Cloudsley Rutter of the United States Fish Commission gives the story of the Sacramento salmon in very unique fashion. A full account is given of each detail in the life history of the fish, together with photographs of scenes and places on the salmon's route, and a very large number of illustrative drawings. Among the fantastic stories of animals now in vogue, many of them having no existence in real nature as distinguished from the forests of Kiplingia, it is refreshing to find a fish story, at once natural and true, the result of years of patient observation.

In the *Proceedings of the United States National Museum* (Vol. XXIV, Nos. 1260, 1261, and 1263) Jordan and Snyder continue their monographic reviews of Japanese fishes, treating the various forms combined by Günther under the head of Trachinidæ. They follow Boulenger in separating from this group all the species with thoracic ventrals as being percoid rather than trachinoid in their affinities. Twenty-six species are enumerated, seven being new. Three new genera, Pteropsaron, Ariscopus, and Stalix, are described and figured. Of the Discoboli, four species are enumerated, *Lethotremus awæ* and *Crystallias matsushimæ* being new, the latter the type of a new

genus near Liparis. The Embiotocidæ, or surf fishes, consist of two species in Japan, *Ditrema temminckii* and *Neoditrema ransonneti.* The Pediculati, or angler fishes, of Japan consist of eleven species, the following being new: *Antennarius nox*, *A. scriptissimus*, *A. sanguifluus*, *Malthopsis tiarella.* The last two papers are by Dr. Jordan, assisted by a Japanese student of fishes, Michitaro Sindo.

Mr. William H. Gregg has published a convenient volume on *When, Where, and How to catch Fish on the East Coast of Florida.* The greater part of the book is devoted to a systematic account of the game fishes of the east coast of Florida, with numerous figures taken from government publications. The systematic part is arranged from the writings of Jordan and Evermann, which is very proper when credit is given, as Mr. Gregg has been careful to do. To make popular works of this sort possible is one of the duties of the systematist. After describing the fishes Mr. Gregg tells in an accurate and readable fashion how and when to catch them.

In the *Annals and Magazine of Natural History* (Vol. IX, No. 51), Dr. G. A. Boulenger discusses the classification of the berycoid fishes. He finds that this group differs from the percoids in no important respect, and regards the berycoids as merely archaic percoids. The chief diagnostic character, the increased number of ventral rays, is found in most berycoids. Pempheris, however, differs from Beryx almost solely in having the usual number of ventral rays, I, 5, found in most spiny-rayed fishes. Zeus and Grammicolepis, perhaps not related to Beryx, have also an increased number. Aphredoderus is placed among the berycoids by Boulenger. The resemblance of the fossil genus Asineops to the Berycidæ is also noted, while Erismatopterus is thought to have no near affinity. To the present writer Erismatopterus resembles the Percopsidæ, having much in common with Columbia. Boulenger rightly separates Pempheris from the Kurtidæ, and he suggests the close relationship of both Pempheris and Bathyclupea to Beryx. Stephanoberyx and Malacosarcus he would place among the Haplomi. Polymixia he regards as an ally of Beryx, and Morocentris as a more distant relative. Hoplostethus he unites with Trachichthys, while a new genus, Gephyroberyx, is proposed for *Trachichthys darwini.* The genus Paratrachichthys with the vent advanced is rightly regarded as valid. D. S. J.

Twenty New Pocket Mice. — Pocket mice are mice with pockets, not mice intended to be kept in the pocket, as the reader may innocently suppose. Dr. C. H. Merriam (*Proc. Biol. Soc. Washington*,

March 5, 1902) has given us a most important contribution to the knowledge of these animals, principally based on the material (some 800 specimens) collected by Messrs. Nelson and Goldman in Mexico. The genus Heteromys takes the place of our common Perognathus in the warmer parts of Mexico and in Central America, but comes north (as Dr. Merriam's paper shows) into the states of Chihuahua and Sonora, and to Brownsville, Texas. However, these more northern animals, along with a number of others, represent a type so far departing from typical Heteromys that Dr. Merriam segregates them under a new generic name, Liomys. The type of the new genus is *Liomys alleni*, — the *Heteromys alleni* of Coues, 1881.

Taking Heteromys and Liomys together, and considering only the fauna of America north of Panama, no species were known previous to 1868, when Gray described four. In 1874 Peters described one, in 1881 Coues one, in 1893 Thomas published four, and two were made known by Allen and Chapman in 1897. Thus, in all, twelve were known; and to these Dr. Merriam now adds twenty!

T. D. A. C.

Osteology of the Flamingoes. — Dr. R. W. Shufeldt[1] describes the skeleton of the flamingo (*Phœnicopterus ruber*) with special reference to the relations of the flamingoes to the Anseres (ducks, geese, swans) on the one hand, and to the Herodiones (ibises, herons, storks) on the other. The author compares minutely the flamingo skeleton, bone by bone, with the skeletons of representatives of the other groups. On the whole, the flamingo skeleton presents a mixture of anserine and ibidine characters, together with certain characters which are distinctly peculiar to itself. For the most part there is no marked predominance of either anserine or ibidine features. In furcula, coracoid, and wing skeleton, the anserine characters are in excess. The tarso-metatarsus resembles most closely that of an ibis.

The author concludes that, so far as the skeleton is concerned, the flamingoes should constitute an independent group or suborder (Odontoglossæ, corresponding to Huxley's Amphimorphæ) standing between the anserine and pelargo-ibidine forms.

H. W. R.

Regeneration in Hydra viridis. — *Hydra viridis* has been made the subject of a series of regenerating and grafting experiments by

[1] Shufeldt, R. W. Osteology of the Flamingoes, *Annals of the Carnegie Museum*, vol. i (1901), pp. 295–324, Pls. IX–XIV.

Dr. Helen Dean King.[1] It was found that the removal of the oral end by a cut just below the tentacles was followed by the regeneration of fewer tentacles than were possessed originally, while the diameter of the regenerated hypostome was less than that of the original hypostome. As this operation reduces the volume of the body, the result appears to agree with the view advanced by Parke[2] (p. 702), "that a certain ratio exists between the size of a Hydra and its number of tentacles, and that when this ratio is destroyed by an increase or decrease in size of the Hydra, there will be an increase or decrease in the number of tentacles of that Hydra." When the tentacles were removed by cutting at the base of each one so as not to diminish the volume of the trunk, in most cases as many tentacles were regenerated as had been removed.

The severed "heads" remodeled themselves into small polyps, and, although the hypostomes suffered reduction in diameter, in no case was a reduction in the number of tentacles observed, in spite of the smallness of the polyps. This, the author maintains, does not support Parke's view. (It should be noted, however, that Parke's statement was made with reference only to change of size resulting from favorable or unfavorable conditions, — not to decrease in volume by the mechanical removal of part of the body.)

Double-headed forms were produced by splitting the oral end longitudinally. When the tentacles were first removed, the total number of tentacles ultimately borne by the two heads together was an average of 3.4 tentacles per hydra greater than the number originally borne. When the tentacles were not removed previous to the splitting of the oral end, the average number of new tentacles developed by the two heads together was 5.1 per hydra. These double-headed polyps resolve themselves into two polyps by what resembles a process of longitudinal division, the final separation occurring at the extreme aboral end. Some of these double-headed forms were made to attach themselves oral end downwards. The separation of the two parts occurred at the aboral (upper) end as before, proving that the longitudinal fission is not due simply to the constant strain exerted by gravity at the point of divergence of the two branches of the trunk.

[1] King, Helen Dean. Observations and Experiments on Regeneration in Hydra viridis, *Arch. für Entwickelungsmech. der Organismen*, Bd. xiii. Hefte 1 and 2 (1901), pp. 135–178. 31 text-figs.

[2] Parke, H. H. Variation and Regulation of Abnormalities in Hydra, *Arch. für Entwickelungsmech. der Organismen*, Bd. x, Heft 4 (1900), pp. 692–710. 9 text-figs.

If the cut edges of a split oral end are permitted to reunite, new tentacles develop at the regions of union. Polyps with fourteen tentacles were thus produced, but the repetition of the operation on a fourteen-tentacled hydra resulted in no further increase of tentacles.

Attempts were made to secure heteromorphosis, or reversal of "polarity," by grafting. In several cases tentacles were developed upon an aboral cut surface or a foot upon an oral cut surface, but in all these cases (which the author interprets as heteromorphosis) the pieces whose polarity appeared to be reversed were very small parts of the trunk. In the case of a graft of any considerable length, the free cut end reproduced parts similar to those which had been cut away from it. In the cases of apparent heteromorphosis exhibited by very small fragments of the trunk, can it be proved that there is not a shifting about of the tissues or a migration of cells, so that the regeneration does not really involve a reversal of polarity?

H. W. R.

A Revised Classification of the Enteropneusta. — It is nine years since Spengel's great monograph of this group was published.

A number of important additions to our knowledge have been made in the meantime, and the author now returns to the subject[1] for the purpose of recasting the systematic arrangement of the species, and rectifying certain violations of nomenclature which the monograph contained.

The total number of species has been increased by thirteen, and information about one of the old species, *viz.*, *Ptychodera flava* Eschscholtz, has been largely extended since the publication of the monograph.

A total of twenty-nine species is now recognized by the author. The arrangement of these into families and genera is as follows:

FAMILY I. HARRIMANIIDÆ SPENGEL, 1901.

Genus 1. *Harrimania* Ritter, 1900.
" 2. *Dolichoglossus* Spengel, 1893.
" 3. *Stereobalanus* Spengel, 1901.

FAMILY II. GLANDICIPITIDÆ SPENGEL, 1901.

Genus 1. *Glandiceps* Spengel, 1901.
" 2. *Spengelia* Willey, 1898.
" 3. *Schizocardium* Spengel, 1891.

[1] Die Benennung der Enteropneusten-Gattungen, *Zool. Jahrbuch*, Abth. für Systematik, Geographie, und Biologie der Thiere, Bd. xv, Heft 2, 1901.

Family III. Ptychoderidæ Spengel, 1893.

Genus 1. *Glossobalanus* Spengel, 1901.
" 2. *Balanoglossus* Delle Chiaje, 1929.
" 3. *Ptychodera* Eschscholtz, 1825.

The classification adopted by the author in his monograph was unfortunate in that it conflicted at several points with established rules of nomenclature. For example, the type species of Ptychodera, *P. flava* Eschscholtz, 1825, would have been removed by Spengel to a new genus, Tauroglossus. Delle Chiaje's well-known species, *Balanoglossus clavigerus*, was likewise deprived of its original generic name and placed in the suggested genus Tauroglossus.

Both these pioneer species are now restored to their rightful places as types of the genera to which they were originally assigned.

This latest scheme of classification of the Enteropneusta undoubtedly corresponds nearer to the actual relationship of the species than any other that has been proposed.

As the author remarks, however, the three genera constituting the Harrimaniidæ are certainly considerably less closely related than are those constituting the other two families.

Dolichoglossus in particular, I would remark, is much less close of kin to the other genera of the family than these genera are to each other.

Wm. E. Ritter.

Hymenoptera Parasitica Hawaiiensis. — The part of the *Fauna Hawaiiensis* (Vol. I, Part III) dealing with the parasitic Hymenoptera has just come to hand. It is written by Mr. W. H. Ashmead, who has prefaced to the purely descriptive part some very interesting remarks on the Hymenoptera of the Hawaiian group. Of the 128 parasitica enumerated, no less than 87 are described as new; these do not include any which cannot be referred to known families, but eleven genera appear to be endemic. Several of the previously known species are easily recognized as introductions from other parts of the world. Mr. Ashmead suggests that the list as given must quite inadequately represent the actual fauna, "since many of the common parasitic families, which must surely occur, are entirely unrepresented." Since writing these words, Mr. Ashmead has himself visited the islands, and no doubt he will shortly publish the results of his own collecting; but it may be pointed out that the condition observed is characteristic of oceanic islands in general, and of the Hawaiian Islands in particular, as may be seen by reference to Wallace's *Island Life*, second edition, Chapter XV. Hence,

if the missing families turn up, we may subject their representatives to close scrutiny in respect to their actual origin upon the islands. The Coccidæ of the Hawaiian Islands are quite numerous, and some have been first described from Hawaii; but evidence has now accumulated which renders it extremely probable that all the species reported have been introduced by man, and I am very much inclined to doubt the existence of a single endemic Hawaiian Coccid. Probably the same may be said of the Hawaiian ants, which are all of well-known continental genera. The bees of the islands (excluding the honey-bee) belong to only three genera, and it is interesting to note that these are all borers in the trunks or stems of plants. The bees which burrow in the ground are wholly absent. T. D. A. C.

The Slugs of Borneo. — The naked land-mollusca of Borneo have been made the subject of an interesting paper by Mr. W. E. Collinge (*Trans. Royal Soc. Edinburgh*, Vol. XL, Part II, No. 15). The species known from the island, twenty-seven in all, are enumerated, two genera (Wiegmannia and Isselentia) and nine species being described as new. The type species of Wiegmannia (a genus of four species) is not stated; we may designate as such *W. gigas*, Collinge, which is the largest species; for although *W. dubia* (Wgm.) was the first described, it was not examined by the author of the genus.

T. D. A. C.

BOTANY.

Meier's "Herbarium and Plant Description" [1] is a portfolio containing twenty-five sheets folded to 11×8½ inches, one inside page being blank for the attachment of a dried specimen, and the other ruled and spaced for a description of the various organs of the plant, drawings, and other notes. On the front cover inside are concise directions for collecting, pressing, and mounting, and at the back is a ruled page for indexing the collection. The whole forms a simple arrangement meeting the usual requirements for pupil's herbariums and for such meager descriptions as are too often deemed sufficient in school work. It has the advantage, however, over many similar schemes for recording plant analyses, that ample space is afforded by the outside pages of each folder for additional notes. F. L. S.

[1] Meier, W. H. D., Superintendent of Schools, Griggsville, Ill. *Herbarium and Plant Description.* Boston, Ginn & Company.

Leavitt's "Outlines of Botany" [1] follows substantially the general sequence of topics in Gray's *Lessons*, and retains much of what must always be highly valuable in that classic text-book. At the same time so many modifications and additions have been required to meet the needs of high schools to-day that a really new book is the result, and one that is fresh and modern in treatment, broad in scope, yet wisely restricted to parts of the subject appropriate for beginners.

The most radical departure is in the laboratory studies, which in important ways improve upon previous attempts to solve the same pedagogical problems. Instead of being frequent interruptions to the text they are kept in sections by themselves, each preceding the section of text to which it relates. They consist of explicit directions and skillfully worded questions leading the student to intelligent observation of readily obtainable material and to instructive experimentation. In addition to these aids to laboratory work many helpful suggestions to teachers are given in an appendix, while a number of good references for supplementary reading are included for the benefit of both teacher and pupil.

In the text ecological considerations play an effective though subordinate part in accounting for peculiarities in the form and behavior of organs. Primarily, however, the study of the parts of plants is firmly grounded upon their morphology. A considerable number of new figures, all of high excellence, supplement or replace those of the *Lessons*.

The work is sure to be heartily welcomed by a large number of teachers, whether among those who are struggling to make the best of meager equipment and much restricted time, or among those who are more fortunate in their opportunities. Those who use the book cannot fail to be impressed by the fine scientific spirit which animates every page. F. L. SARGENT.

Garden Beans. [2] — Few attempts have been made to monograph the garden beans. The work of von Martens, *Die Gartenbohnen*, in 1860 seems to have been the only previous effort in this direction.

[1] Leavitt, Robert Greenleaf, A.M., of the Ames Botanical Laboratory. *Outlines of Botany*, for the High School Laboratory and Classroom (based on Gray's *Lessons in Botany*). Prepared at the request of the Botanical Department of Harvard University. New York, American Book Company. 12mo, 372 pp., 384 figs.

[2] Irish, H. C. Garden Beans cultivated as Esculents. *Report Missouri Botanical Garden*, vol. xii, pp. 81–165, Pls. XXXVIII–XLVII.

Since that time the varieties of garden beans have greatly increased in Europe and the United States. All of the leading varieties of America and Europe were cultivated at the Missouri Botanical Garden, so that the growth and seed characters were used in the descriptions. The garden beans are grouped under the following genera: Phaseolus, Dolichos, Vigna, Glycine, and Vicia. The author gives a short account of the origin, uses, methods of culture, with a brief account of *Bruchus obsoletus* and *Colletotrichum lagenarium*, *Uromyces phaseoli*, and *Phytopthora phaseoli*. Three species of the genus Phaseolus are described, *P. lunatus*, *P. vulgaris*, and *P. multiflorus*. The greatest number of varieties are listed under *P. vulgaris*. Dolichos is represented by *D. lablab* and *D. sesquipedalis;* Vigna is represented by *V. catjang;* Glycine by *G. hispida*, of which five garden varieties are listed, but this does not by any means comprise all of the varieties, as they are numerous in Japan and China, where the species has long been cultivated. The genus Vicia is represented by a single species, *V. faba*.

An excellent feature of the paper is the full citation of the literature of the genus as well as that of the species, no pains having been spared to verify references. The half-tone plates accompanying the paper greatly aid in the botanical study of the garden beans. The excellent keys for garden varieties also help to facilitate the determination of the garden forms. This is one of the most important contributions to horticultural literature in this country. In point of thoroughness it is like his paper on Capsicum published a few years ago in one of the earlier reports of the Garden. It is a model of excellence in every way, and it may well serve as a guide for much of the erratic work carried on in this country in listing varieties and describing the same.

The work carried out by the author is one that has long been neglected in this country. Mr. Irish is fortunate in having had at his disposal not only a large amount of material,—and such work can only be undertaken where this is at hand,—but also a good reference library, combined with acute judgment in discriminating between the puzzling garden forms.

L. H. Pammel.

Pfeffer's Plant Physiology. — Pfeffer's[1] revision of his *Pflanzenphysiologie* has been so thorough and so time-consuming that only the

[1] Pfeffer, W. *Pflanzenphysiologie. Handbuch der Lehre vom Stoffwechsel und Kraftwechsel in der Pflanze.* 2. Auflage. Leipzig, Engelmann, 1901. Bd. ii. 1. Hälfte.

first half of Vol. II has been made ready for publication. This first part appeared last summer. The first volume, reviewed in this journal (Vol. XXXII, pp. 450, 451, 1898), treated the subjects comprehended under metabolism. The first half of the second volume discusses growth and the factors that control it, development, variation, and inheritance — in short, different kinds of work done by the plant, dependent upon and made possible by the processes discussed in the earlier volume. In a book planned as this is, with the first volume devoted to the transformation of matter and the second to the transformation of energy, more or less repetition is necessary, but it is a repetition which gives to Pfeffer's treatment of the subjects in plant physiology the exhaustiveness which the physiologist needs. This is no book to be put into the hands of undergraduates; it is for the man who has studied long and is studying hard. However much one may wish that Pfeffer's literary style were not so difficult, one cannot help recognizing that it is full of meaning.

The arrangement of matter in Vol. II of the second edition differs somewhat from the first edition; consequently comparison of the two editions as to size is difficult. One sees at once, however, that if the second half of the volume is to treat the subjects of movements and the production of heat, light, and electricity in anything like proportional fullness, the book will be considerably larger than in the first edition. The additions to the first part are many of them the results of Pfeffer's own work, either investigation or teaching. This will be equally true of the second part of the volume.

Such a work as this, presenting the status of a science as a whole, shows where the great gaps in our knowledge are. For instance the plant physiology of to-day consists of the facts discovered in studying land and fresh-water plants, and of the interpretations of these facts. Indeed, the fresh-water algæ have taken only a minor place as subjects of physiological inquiry, so that we have to-day a physiology interpreted by too many in terms applicable to land plants only. The laboratory guides carry this to the extreme, but they show how one-sided our knowledge is. Pfeffer's book can contain only a few references to the marine algæ. I am convinced that the careful physiological study of marine plants, though such study may reveal no new principles, will modify and correct many of the conceptions prevailing to-day. The status of the science is satisfactory, but there is room for much more research.

G. J. P.

Trees in Winter. — Every observer knows that there are other ways of recognizing animals and plants than those given by the books, and we all welcome every addition to the literature of these occult ways of coming into touch with nature. That trees may, in general, be recognized as certainly in winter as at other seasons has long been known, and little handbooks codifying their winter characters have appeared in most European countries, and similar keys, etc., have appeared several times in our own country, but unfortunately usually in transient pamphlet form.

There is now published a neat and accurate little book[1] dealing with the more obviously marked deciduous trees of northeastern America, the characteristic traits of which are shown by habit half-tones, and the twig details by three-color plates. Professor Sargent stands as godfather to the book, which will be an ornament to any center table, and should do much to give incentive to those walks in winter that the few enjoy so keenly and the many forego because they lack a direct object.

T.

Notes. — Vol. V of the *Annuaire du Conservatoire et du Jardin Botanique de Genève* contains M. Briquet's administrative report; a paper by him on the flora of the mountains of Corsica; an enumeration by Hochreutiner of Malvaceæ collected by Chevalier in central Africa; a paper by Wettstein on Gentiana and Euphrasia; a revision of Urena by Hochreutiner; a paper by Briquet on Alpine Hieracia; notes on Malope and Palaua by Hochreutiner; a description of *Poa balfourii*, from the Alps, by Briquet; studies of some American Nyctaginaceæ by Heimerl; and an exchange seed list.

The *Bulletin of the Torrey Botanical Club* for January contains the following articles: Salmon, "Supplementary notes on the Erysiphaceæ"; Anderson, "*Dasyscypha resinaria* causing Canker Growth on *Abies balsamea* in Minnesota" (2 pls.); Anderson, "*Tilletia horrida* on Rice Plant in South Carolina"; and Rennert, "Seeds and Seedlings of *Arisæma triphyllum* and *A. dracontium*" (1 pl.).

A new edition of *Dörfler's Botaniker-Adressbuch* has recently been issued by the editor, and bears the imprint of Vienna.

The principal articles contained in the *Botanical Gazette* for January are the following: Harper, "Binucleate Cells in Certain Hymenomycetes" (1 pl.); Clark, "On the Toxic Properties of

[1] Huntington, Annie Oakes. *Studies of Trees in Winter.* Illustrated with colored plates and photographs. Boston, Knight Millet, 1902. xviii + 198 pp.

Some Copper Compounds with Special Reference to Bordeaux Mixture" (7 figs.); Clinton, "*Cladochytrium alismatis*" (3 pls.); Arthur, "Clues to Relationship among Heterœcious Plant Hosts"; Gooding, "Rocky Mountain Plant Studies, I."

The January number of *Country Life in America* is a California number. Among things of interest to the botanist are excellent habit photograms of *Washingtonia filifera*, *Sequoia gigantea*, *Quercus lobata*, *Yucca arborescens*, and the famous Monterey cypresses, and an exquisite flower portrait of *Romneya coulteri*.

In *Country Life in America* for February Mrs. Comstock writes on trees, Mr. Davy on the poppyworts, the editor on the nature-study idea, and Mr. Mowbray on the gardens of the old Hudson River manors. Many of the half-tone illustrations are not only exquisite but of botanical value.

The fifth fascicle of Vol. I of Mr. Howell's *Flora of Northwest America* reaches into the genus Plantago, the Benthamian sequence being followed. Like preceding parts, it contains descriptions of a few new species.

A phytogeographic paper on Silesia, by Schube, is published as a complementary Heft to Bd. LXXVIII of the *Jahresbericht der Schlesischen Gesellschaft für vaterländische Cultur*.

Vol. XVI of the *Acata societatis pro fauna et flora fennica* is entirely devoted to papers discussing the flora of the country.

In Vol. XIII of the *Verhandlungen der Naturforschenden Gesellschaft in Basel* Binz gives an interesting comparison of the present flora of that part of Switzerland in comparison with what Bauhin knew of it three centuries ago.

Vol. IV of Engler and Drude's *Vegetation der Erde* is by Beck von Mannagetta, and deals with the Illyrian region. It is published by Engelmann of Leipzig.

A historical bibliography of the flora of Rome is in course of publication by Pirotta and Chiovenda, in the *Annuario* of the botanical institute of that city.

A second part of Ross' "Beiträge zur Flora von Sizilien" is published in No. 12 of the *Bulletin de l'Herbier Boissier* for 1901.

A paper on Dr. Baldacci's Albanian collections of 1897 has recently been separately printed from the *Memoire* of the Bologna Academy.

A list of new plants from the Cape Peninsula is published by Major Wolley Dod in the December number of the *Journal of Botany.*

An account of the vegetation of the Caroline Islands, by Volkens, is published in Bd. XXXI, Heft 3, of the *Botanische Jahrbücher.* Several interesting process plates accompany the text.

Several botanical papers are contained in the recently issued second part of Vol. XXVI of *Proceedings of the Linnean Society of New South Wales.*

Vol. XXXIII of the *Transactions and Proceedings of the New Zealand Institute* contains the following botanical papers: Cockagne, "Seedling Forms of New Zealand Phanerogams," "Gunnera and Myosotis in Chatham Islands"; Laing, "Seaweeds of Norfolk Island"; Walsh, "*Cordyline terminalis* in New Zealand"; Cheeseman, "Cultivated Food Plants of the Polynesians, with Special Reference to *Cordyline terminalis,*" "Recent Additions to the New Zealand Flora"; Thomson, "Plant-Acclimatisation in New Zealand"; Rutland, "Regrowth of the Totara"; Petrie, "Descriptions of New Native Plants"; Brown, "Notes on the New Zealand Musci." In the *Proceedings of the Affiliated Societies* some minor botanical notes are given, among them a rather curious surmise concerning *Selaginella lepidophylla.*

The announcement of the Marine Biological Laboratory at Woods Hole sets forth an attractive programme of studies and lectures for the coming summer. In the department of botany courses are provided in cryptogamic botany by Dr. Dacis, Dr. Moore, and Mr. A. C. Moore; in ecology by Dr. Cowles and Dr. Shaw; in plant physiology by Dr. R. H. True, and in cytology by Dr. Davis and Mr. Wolfe. In addition to the work of the session, which will extend from July 2 to August 13, an expedition will be organized to Mt. Katahdin and the coast of Maine for the purpose of conducting ecological studies in that region.

CORRESPONDENCE.

Editor of the American Naturalist:

SIR: — In a paper on "The Colors of Northern Polypetalous Flowers," in the March number of the *Naturalist*, p. 295, Mr. Lovell states that *Halictus nelumbonis* confines its visits to the flowers of *Nuphar* (*Nymphæa*) *advena*. In *Transactions of the American Entomological Society*, Vol. XVII, p. 316, 1890, it is recorded that this bee was taken on flowers of Nuphar, Nymphæa, and Nelumbo in Illinois, on Nuphar and Nymphæa in Florida, and on Nuphar in Wisconsin. It has been mentioned as a general visitor of Nymphæaceæ in *American Naturalist*, Vol. XXIX, p. 107; *Botanical Gazette*, Vol. XXVI, pp. 29, 36; *Illustrirte Zeitschrift für Entomologie*, Bd. V, p. 310; *Botanisches Centralblatt*, Bd. LXXXV, pp. 299, 302; *Botanischer Jahresbericht*, Bd. XXVII, Abth. 2, p. 463. No doubt the female gets pollen exclusively from flowers of Nymphæaceæ; but I have found her visiting for nectar the flowers of *Eriocaulon gnaphalodes*, *Utricularia inflata*, *Berlandiera subacaulis*, and *Verbena urticifolia*.

On page 235, in regard to the visitors of Umbelliferæ, he says: "In Germany there have been collected on the caraway 55, on the wild carrot 61, and on the wild parsnip 118 insects. Probably the number of visitors to many species exceeds 200." The plant called wild parsnip by Mr. Lovell is *Heracleum spondylium*. In *Transactions of the Academy of Science of St. Louis*, Vol. V, p. 459, 1890; *Botanisches Centralblatt*, Bd. XLVI, p. 110; *Botanischer Jahresbericht*, Bd. XVIII, Abth. 1, p. 509, visitors are credited to several species as follows: *Zizia aurea*, 131; *Eryngium yuccifolium*, 147; *Tiedemannia rigida*, 156; *Heracleum lanatum*, 174; *Sium cicutifolium*, 191; *Cicuta maculata*, 238; *Pastinaca sativa*, 275.

In the literature the status of Müller's view regarding the influence of dull yellow colors on the visits of beetles is about as follows: The general proposition was refuted by Bonnier in 1879.[1] In the Tyrol, Schulz[2] not only found beetles on such flowers, but also distinctly stated that the general proposition was not true for that region.

[1] Les nectaires, *Ann. Sci. Nat. Bot.*, ser. vi, vol. 8, p. 71.

[2] Beiträge zur Kenntniss der Bestäubungseinrichtungen und Geschlechtsvertheilung bei den Pflanzen. Bd. ii (1890), p. 64.

In the same year I discussed the subject in connection with the Umbelliferæ,[1] enumerating the visits of forty species of beetles to flowers of Pastinaca, which is nearly twice as many as Müller ever found on any umbellifer. In the *Botanical Gazette*, Vol. XXII, p. 169, 1896, I have cited the statements of Bonnier and Schulz. Finally, Knuth,[2] in a volume devoted to the general principles of anthoecology, abandons Müller's view with the statement that Müller himself and Loew had made observations which did not support it. He does not mention the observations of Bonnier, Schulz, or mine; but, of course, when a man feels at liberty to use the literature in any way he likes, he can record old things as new, and give credit in any way that suits his fancy. These references ought to be enough to dispose of a proposition which was never supported by a reasonable presumption.

CHARLES ROBERTSON.

CARLINVILLE, ILL., April 4, 1902.

[1] *Trans. Acad. Sci. St. Louis*, vol. v (1890), p. 454.
[2] Handbuch der Blütenbiologie, Bd. i (1898), p. 224.

(*No. 426 was mailed June 18.*)

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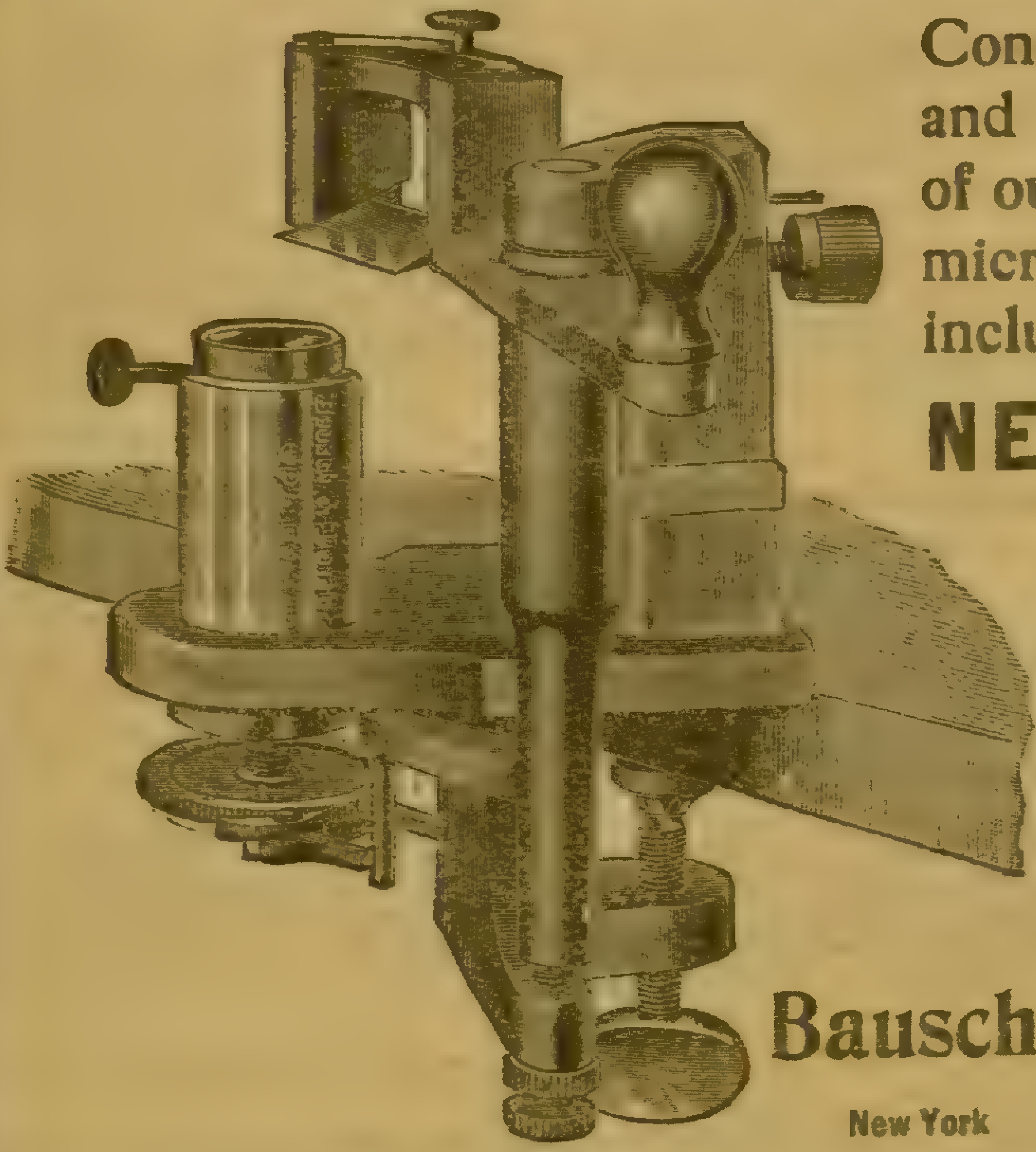

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VOL. XXXVI, NO. 428 AUGUST, 1902

THE AMERICAN NATURALIST

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IN THEIR WIDEST SENSE

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THE

AMERICAN NATURALIST

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THE ANATOMY OF A DOUBLE CALF.

HENRY LESLIE OSBORN.

The subject of this article is a Durham calf born near Minneapolis, Minn., in March, 1901. It lived only ten minutes; but excepting that there was a fracture in the hip bone no indication of injury was seen, and the different organs presented such a healthy appearance as to justify the belief that the calf could have been reared by taking special pains to that end. I owe the opportunity to examine the case to Mr. H. W. Howling, a taxidermist of Minneapolis, who sent me the carcass after the removal of the skin. I am indebted to Dr. C. Hart Merriam, Washington, D.C., for an introduction to the literature of teratology.

The appearance of the stuffed skin is shown in the two photographs, Figs. 1 and 2, views from behind and from the dorsal surface. There are two perfect anterior bodies, each with its head and thorax and the anterior part of the abdomen, and there are four perfect anterior limbs. The left body appears in the mounted condition (see Fig. 2) to be a complete body, into the side of which the anterior right half has been grafted at an angle of about ninety degrees. The hind legs stand nearly at

right angles with the axis of the left half, while they are nearly in the plane of the axis of the right. The internal structure, however, as will be seen, shows that in reality there are two nearly complete bodies strangely united to form the animal. Posteriorly the two bodies are united to form a single region, standing on a right and left hind leg, each of which belongs to one of the anterior halves of the body. There is a third hind leg. It does not touch the ground, but arises from the center

FIG. 1. — View of stuffed skin from behind, from a photograph.

of the rump and projects backward and to the left. This leg has the usual form and regions. Of course I have no means of knowing its bony structure, but it shows the same external subdivisions as the others and ends in two hoofs; the limb, however, is shorter than the others, as shown in this table of measurements.

	LEG.	FORE LEG.	FOOT.	HOOF.
Right hind leg	11 in.	8 in.	3 in.	1½ in.
Middle hind leg	6 in.	6 in.	3 in.	1½ in.

There are two tails, of the same form and size. They are symmetrical in position, each located between the functional hind leg of its own side and the middle leg. The anus is single; it is located directly under the median hind limb and equally distant from the tails. No indication of a urogenital opening was seen, and the structure of the bladder indicates that the penis had not been formed.

The coloration of the skin exhibits noticeable bilateral symmetry; the general ground color is brown, on which white spots,

F'- 2. — View of dorsal surface, from a photograph.

or areas, are found closely matching each other as to position and shape. On the top of each head is a white spot of much the same position, size, and shape; the two tails end in white, of the same length in each. The limbs are white below, except the inner fore limbs, both of which are brown to the carpal region, and the right to the toe in addition. A girdle of white encircles the body of each; it is more solid on the left side. There is a patch on the loin region of each. The following measurements were made from the mounted animal:

Height of body at hip . . .	27 in.	Length of right tail	13 in.
Base of tail to tip of right nose	35 in.	" left "	13 in.
" " " left "	35 in.		

The body as it reached my hand had the skin removed, and the heads and lower limbs. The external points noticed were these: There was a single anus; a single median umbilical opening was present; there were two bilaterally placed testes located on the wall; they had passed to the surface but no scrotum was formed; they were somewhat widely apart (four inches?); a penis was not present. There are two complete spinal columns, as would be inferred from the presence of two

FIG. 3. — Dorsal aspect of the bones of the sacral region.

tails. They are, however, both considerably modified in and behind the lumbar region, as shown in Figs. 3 and 4, which are dorsal and ventral views of the osteological preparation of that region. Both columns are evidently present; they come toward each other and then bend into parallelism, the right becoming concave on the right side, and the left on the left side. This is brought about by the outside of each vertebra being considerably smaller than the inside. The transverse processes of the lumbar vertebræ are not much more than half as large on the outside of the vertebra as they are on the opposite

side. The sacral vertebræ are not only bent as described but there is a twist in them so that the centra come to face inwards, and instead of looking downward they look toward each other. Each sacrum articulates on its outer side with an os innominatum of the usual form, consisting of ilium ischium and pubis, meeting to participate in the formation of an acetabulum for the reception of the femur of the paired leg of its own side of the body. The pubic bones meet ventrally and form a normal

FIG. 4. — Ventral aspect of the bones of the sacral region.

symphysis pubis. The two sacra articulate internally with a peculiar bone, evidently composed of two incomplete ilia. This bone presents anteriorly two crests, each with the usual relation to the corresponding sacrum. In the center of this median bone there is a ridge which ends bluntly in front, and posteriorly meets a broad, thin, and somewhat tapering bone by a distinct suture. At the junction of these two parts is situated a shallow but distinct articular surface; it is the acetabulum of the median hind leg. It is very evident that the anterior bone

is composed of parts of two ilia incompletely separated, and that the hinder bone is in like manner made up of the parts of two still less developed ischia, while no traces of the pubes have appeared.

No dissections of the muscular or nervous systems were made, but we can infer from the osteology that there were two complete spinal cords. The innervation of each of the two functional hind legs must have been from the spinal cord of its own side. This separateness of the cord would have seriously affected coördination. It is related that in the two-headed turtle locomotion was very imperfect (Barbour, '**96**), and in Ritta-Christina (Hektoen and Riesman, '**01**) a pinch on the right leg was felt only by Ritta and one on the left only by Christina. The indications from a study of the bones are that the musculature of the outer legs was complete, while the muscles and nerves of the inner side must have been partly, though very incompletely, developed.

The viscera of the thorax were not examined. This is to be regretted, because it would have been important to determine whether the two hearts and vascular systems were counterparts. It seems likely from the anatomy of the animal, so far as known, that they were; still, I am unable to assert the fact. There were two complete diaphragms, and the abdominal cavity was

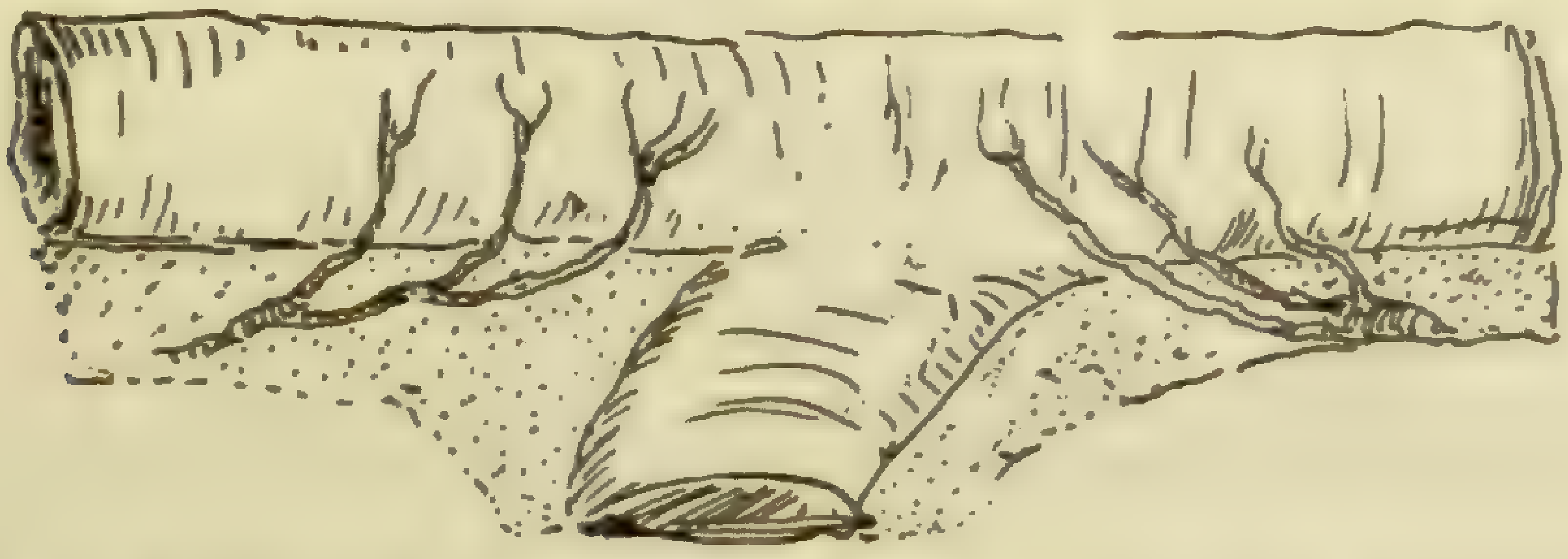

FIG. 5. — Junction of the small intestines of the two anterior bodies, and origin of the single posterior small intestine.

completely subdivided anteriorly. The two livers were entirely distinct, as were also the two stomachs and the upper parts of the intestines. The small intestines run toward each other and meet, forming a continuous tube, as is shown in Fig. 5. There is no indication of a union of two parts at this junction. The vascular supplies of each part are totally distinct, the vessels of

each side running out to reach the common territory. The distance from this junction to the anus is seven feet and two inches, in all of which the intestine is single. The single small intestine arises obliquely out of the common passage, and not, as might be expected, squarely from it. After running a distance of three feet, the small intestine dilates to form the large intestine. Here two cæca of unequal size are located. The two cæca are exactly opposite each other, and their cavities are continuous. At their junction they open together into the intestine at the beginning of the large intestine. The large intestine runs directly to the single anus, a distance of four feet and two inches.

Fig. 6. — The two cæca at the junction of the small and large intestines.

There is normally in the calf only a single cæcum. The presence of two, then, is due to contributions being present from each of the component bodies of the animal. The single intestine could be interpreted in either of two ways, *viz.*, that there was a single intestine into which that of the other half had been engrafted not far from the stomachs, or that the intestine is really parts of two fused in the middle line and thus forming one. The oblique insertion of the single intestine at its origin seems at first to favor the first view, but there is considerable evidence against it. Dr. Wyman ('66), in the case of a double human embryo which he dissected, found that the intestines meet in the middle line and fuse to form a single tube, which, however, soon parts, forming two which run side by side for a time, after which they unite in a single rectum and terminate in a single anus. The presence of the two cæca in the case before us indicates that parts of two intestines, each

running the entire length of the half body to which it belongs, meet in the middle line to form one tube. This mode of origin is in harmony with that seen in the inner iliac and ischial bones and the median hind leg.

The vascular system shows a similar arrangement. Anteriorly there are two complete systems, while posteriorly the systems are complete on the outside, but not entirely so in the central

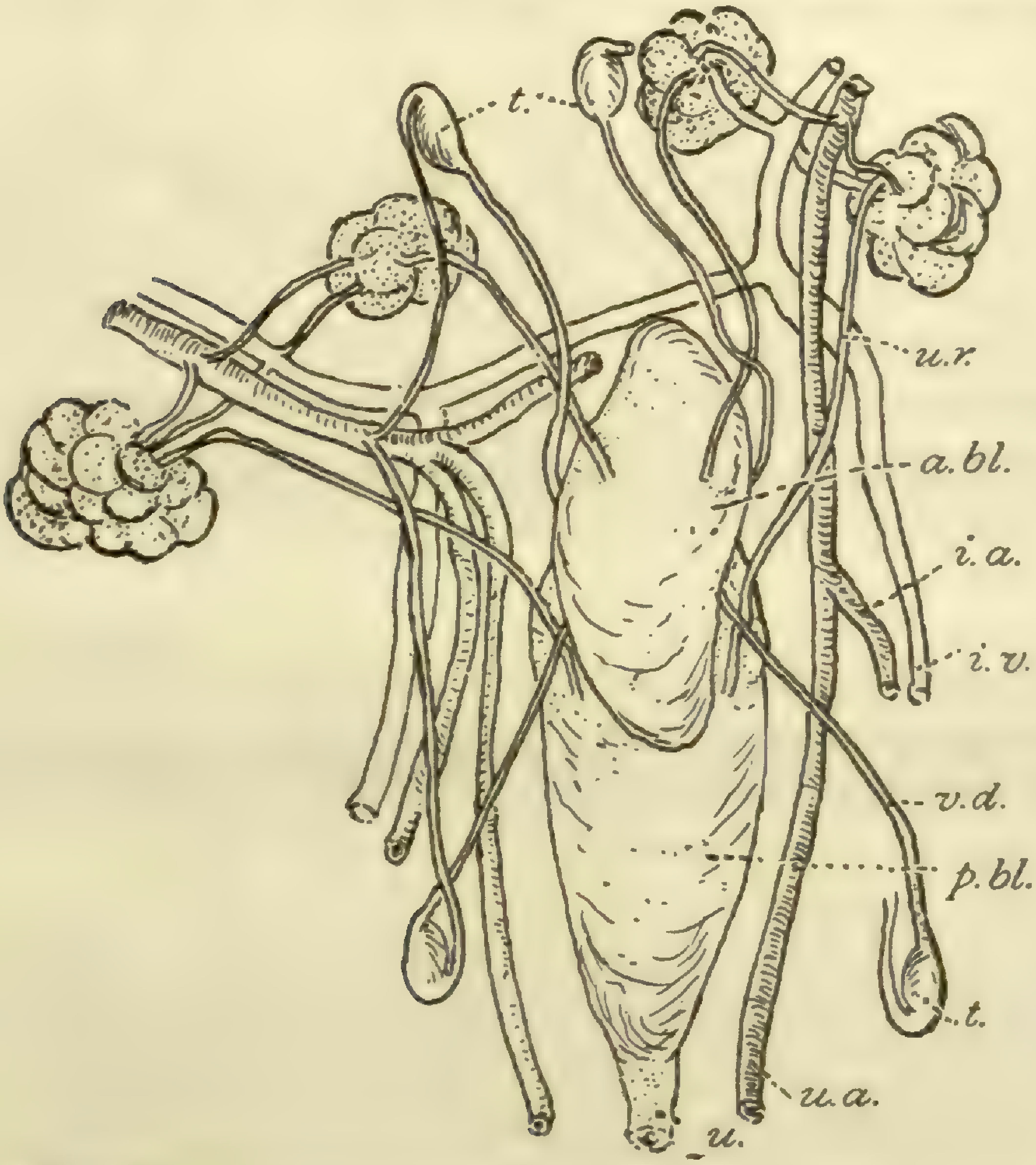

FIG. 7. — The urogenital organs and related blood vessels: *a.bl.*, anterior bladder; *p.bl.*, posterior bladder; *u.*, urachus; *ur.*, ureter; *u.a.*, umbilical artery; *i.a.*, iliac artery; *i.v.*, iliac vein; *t.*, testis; *v.d.*, vas deferens.

area. There are two dorsal aortæ (Fig. 7), and the renal and spermatic arteries are in pairs on both sides, as if the bodies were independent. Posteriorly, however, the aortæ each give rise to one large iliac artery to go to the paired leg of that side, and a second which was not traced beyond the root, where it soon disappeared among the muscles. At the fork of these iliacs a single umbilical artery arises from each aorta; it runs

down alongside of the bladder and, passing out with the urachus, runs to the placenta. A second umbilical artery for each would be needed to complete two entire bodies; these are wholly wanting. There are two posterior venæ cavæ, one for each body half, and similar renal veins were recognized. Posteriorly

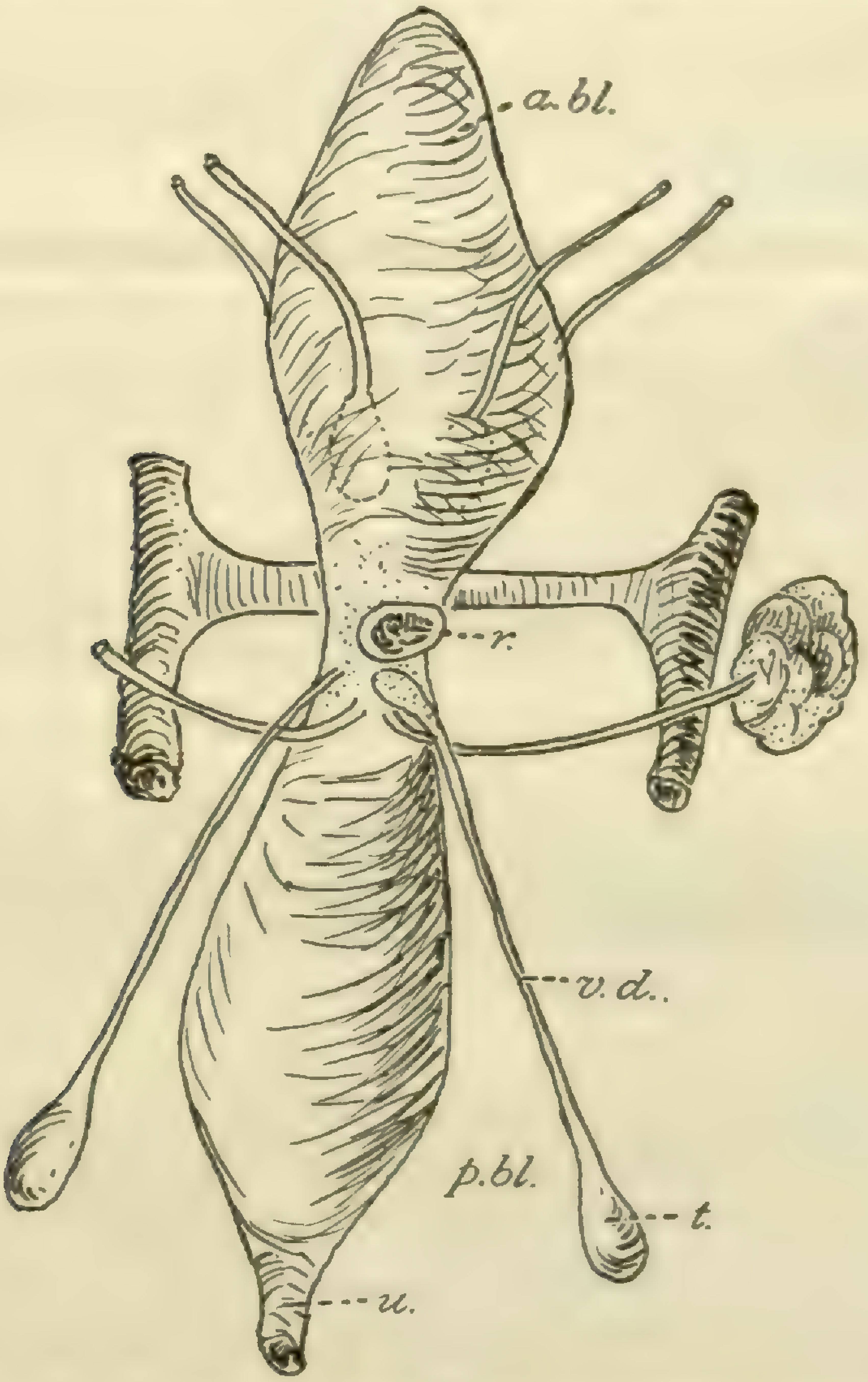

FIG. 8. — The two bladders and related ducts. The anterior bladder has been folded over forward so as to show the anterior surface of the posterior bladder: *r.*, rectum; the other letters as in Fig. 7.

the venæ cavæ divide and give rise, after the manner of the aorta, to an iliac vein for each of the two paired hind legs. But the inner iliac veins run toward each other and meet and fuse, forming a single large communicating iliac vein, thus extending the list of posterior parts common to the two body halves.

There are four complete and independent kidneys; two, by their position and vascular relations, are clearly indicated as belonging to each component body. The kidneys are compound, after the form general in ruminants; each has its hilus looking toward the dorsal aorta, at which three vessels enter its substance, *viz.*, the renal artery, the renal vein, and the ureter. There are two bladders; both are median in position, and one is located in front of the other. They may be designated as the anterior and posterior bladders. They both spring from a common neck, where they are attached indirectly, in common with the end of the rectum, to the body wall. At this place they partly surround the end of the rectum. They are in open communication at the neck by a passage running on the right side of the rectum; but in this region, where the urethra should appear, none is present, and there is no communication here with the exterior. No indications of a penis were found. The posterior bladder had an open urachus whereby it could discharge, but the anterior lacked this entirely, and drained through the passage at the neck into the posterior bladder. The relations of these two bladders is such that the posterior bladder receives the ureters from the two outer kidneys, while the anterior bladder receives those of the inner pair. The ureters of the posterior bladder run down and open into its anterior or dorsal surface, as shown in Fig. 8, and in doing this are aberrant, it being the opposite side to that general in mammals. The anterior pair of ureters are similarly aberrant. Two views are possible with reference to these bladders: either they may be considered as belonging one to each of the two component bodies, in which case we should be obliged to consider that they had, unlike most of the organs of the compound, taken a non-homologous and unsymmetrical position; or else they may be regarded as a single formation common to the two bodies, comparable with the hinder part of the intestine, which has been secondarily subdivided. The latter view seems perhaps more in harmony with the rest of the construction of the body, but decisive evidence cannot be had from the materials furnished in the dissection.

The genital organs show the same relations as the renal system. There are four testes: two are related to the two kidneys of one body and the other two to those of the other. These four testes are, however, paired in the calf not with reference to their individual bodies, but with reference to the compound. Two, as already mentioned, have descended: they are the right of the right body and the left of the left; we may call them the two outer testes. The two inner testes also carry out the symmetry, both remaining in their primitive position beside the kidney. These testes all reach the exterior by means of ducts which have the same relation as do those of the corresponding kidney. Those of the outer testes cross the ureters from the outer kidneys and enter a glandular mass (seminal vesicles?) in the wall of the posterior bladder. The two inner vasa deferentia run down and attach to the anterior bladder, passing as normally to the posterior surface.

The entire urogenital system thus follows the same law of symmetry of the homologous parts as we have seen in the other systems of the animal. This is the more interesting in this case, for in regulating the relations of the ducts from the organs the law comes into conflict with the symmetries of the two individuals and replaces it. This is evidence of the presence of a deeper law of regulation, and indicates the "fission theory" (Hektoen and Riesman, '01) of origin for the monster rather than the "union theory."

The limits of this article do not permit an extensive notice of the literature of teratology; a list of writers consulted is given at the close. Dr. Fisher ('66) gives a figure of a calf much like this one externally, — a case of "diplocephalus tetrabrachius tripus," — but the supplementary hind foot is ventral and anterior, indicating a difference in the mode of union of the pelvic bones. No account of the anatomy is given. He mentions that it was dissected by Dr. Wyman, but I have not been able to get any information of that dissection or its results. The case belongs in the line of double formations, which begins at the minimum with doubling of digits, runs through every stage of double formation of hands, arms, and other parts, of whole regions (as the head and trunk),

and finally culminates in twins: either incompletely separated, as the Siamese twins, or completely separated as in ordinary cases. Authorities in the main assign all such cases to a "division of the ovum imperfectly effected," so that "the resulting bodies instead of becoming complete twins remain united together, frequently having a greater or less extent of the body in common"; thus Bateson (**'94**): "Double formations arise from a fission of the whole or a part of the original embryonic mass." There are two theories as to the process: "one holds that they arise by splitting of the original germinal area of one embryo, and the other that they arise from the fusion more or less of two distinct embryonic areas lying in one ovum" (Hektoen and Riesman, **'01**, p. 419 *et seq.*). The present case indicates a partial fission of the germinal material, that destined to give rise to the anterior parts being wholly divided, while some of that destined for some of the hinder organs remains undivided. This case comes between the Tocci brothers and the Siamese twins. The former of these I have seen, and Fig. 9 is from a photograph of them. In these the hinder part of the body is apparently strictly single; there is less division than in the calf specimen. The Siamese twins were essentially double throughout. In the calf the hind part of the body is incompletely double. There are cases very nearly like it, of which a brief mention will be interesting. The Hungarian sisters, Helen and Judith, had one vertebral column as far forward as the second sacral vertebra; there was a single anus and rectum; both felt the same desire to defecate; there was a single vulva but separate urogenital systems; they urinated separately by different urethra; menstruation came at different periods in each (Hektoen and Riesman, p. 430).

In the case of Ritta-Christina the following items are noted from the account in Gould and Pyle (**'97**, p. 185): umbilical cord and placenta single; heads, necks, arms, and thorax above double; abdomen single; lungs imperfectly double, the central lungs being underdeveloped; one pericardium but two hearts; hearts synchronous; digestive organs separate as far as lower third of ileum, then single to the anus; stomachs, spleen, etc., were right and left; livers right and left were

fused centrally; there were two gall bladders beside each other in the middle line; the uterus was double; the vertebral columns were entire and separated by a mass of bone consisting of fused rudimentary ossa innominata; the sterna were united at their manubria. Reference has been made in an earlier part of this paper to the case of a human fetus dissected by Dr. Jeffries Wyman ('66). It was less double than the calf. There were only three arms, the median one made up of two halves fused; a single pericardium enclosing two hearts; a single lower vena cava branching anteriorly to enter each heart; the umbilical cord had one vein and two arteries. The right and left duodenums came together a short distance from the two stomachs, whose pyloric ends were turned toward each other ("symmetrical counterparts," Bateson, p. 559), but afterward separated and, though side by side, continued distinct nearly to the cæcum, which, as well as the large intestine, was single. There was a single urinary bladder with a double cavity. There were only two kidneys, but they were compound, and each had two ureters,

Fig. 9.—The Tocci brothers, from a photograph in possession of the writer.

one set opening into the upper bladder and a second, much larger, opening into the lower bladder. The bladders had the usual shape, but inwardly the mucous membrane formed a partial partition, near which the two sets of ureters opened. There were also two pairs of testes, one of which were resting on or quite near the kidneys and the other had descended and were "just at the entrance of the inner abdominal ring."[1] This case is much like that of the calf, — the union of the two intestines, the four ureters, and the two bladders, one in front of the other; it is not clear that the outer pair opened into the hinder bladder, but that seems to be intended. The account of the anatomy of the kidneys leaves somewhat to be desired; apparently the fission of the embryonic material had not gone so far here as in the calf specimen as to the kidneys, while it had as to the ducts. The relation of the testes and the ducts seems to have been about the same as in the calf.

Biological Laboratory, Hamline University,
Saint Paul, Minn., April 2, 1902.

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[1] Partly quoted and partly condensed from Wyman's paper.

THE METAMORPHOSIS OF SISYRA.

MAUDE H. ANTHONY.

Sisyra, like most of the Hemerobiidæ, is an insect of whose life history no thorough study has been made, and very little is known of either its habits or metamorphosis. It is an obscure little fly, chiefly interesting on account of some peculiar structures of its larva. The larva has been known since Westwood described it in 1839, but it has never been reared until last summer, at the entomological field station at Saranac Inn, New York. It passes its larval existence as a parasite on fresh-water sponges, clinging to their surfaces or descending into the open osteoles, piercing the sponge tissue with its long decurved jaws. The food thus obtained is so pure as to be wholly absorbed, leaving no residuum. At least one-fourth of the posterior portion of the stomach is atrophied, leaving no opening from the stomach at that end. Carnivorous habits and piercing mouth parts are common to other hemerobian larvæ, but the decurved position of the mouth parts and the tracheal gills are peculiar alone to this insect and Climacia, its nearest ally, which is of similar habits. The singular adaptations of the mouth parts and alimentary tract to the nature of its food I shall describe in detail in this paper.

The most remarkable structure of this larva is the silk-secreting apparatus. In general the silk glands of insects are metamorphosed salivary glands, but in the Sisyra larva they are a modification of the Malpighian tubules; and it seems probable that the nitrogen waste of the body is used, partially at least, in the manufacture of silk. This seems to be another remarkable instance of the economy of the by-product occurring in insect life. No such extensive modification of structure in adaptation to a peculiar environment has been described in any other insect; but two near relatives of Sisyra, Osmylus and Myrmeleon, have a somewhat similar development of silk glands.

The species which I have studied for this paper is *Sisyra umbrata* Needham, and all my specimens were collected for me, a few at Lake Forest and the remainder at Saranac Inn. I have necessarily worked under limitations, not having myself seen any living specimens.

The adult (Fig. 1) is a smoky brown fly, 6–8 mm. long, very hairy, and with the characteristic venation of the Hemerobiidæ, although the wings are not so delicate and transparent as are those of the lacewing flies. The maxilla and labium of the adult, each with peculiar pediform, terminal, palpal joints, are

FIG. 1.—*Sisyra umbrata*, adult. × 10.

shown in Fig. 2. Other parts of the imago — antenna, leg, and wing — are figured and discussed later, in comparison with the same parts in the larva.

The pupa, removed from its double cocoon of finely woven silk, is shown in Fig. 3. It is 4 mm. in length, has two clusters of hairs on the dorsal surface of each segment, and is similar to the larva in color and marking, except that the light median line on the dorsal surface between two dark ones, so apparent in the larva, is not visible. Instead the brown crescent-shaped markings on either side meet in a dark median line.

LARVA — EXTERNAL ANATOMY.

The larva (Fig. 4) is 6 mm. in length, is yellowish green in color, and has quite a distinct color pattern in brown on the dorsal surface. Each of the first seven segments bears, in two dorsal and two lateral groups, twelve projections, except the first abdominal, which has only four on the dorsal surface

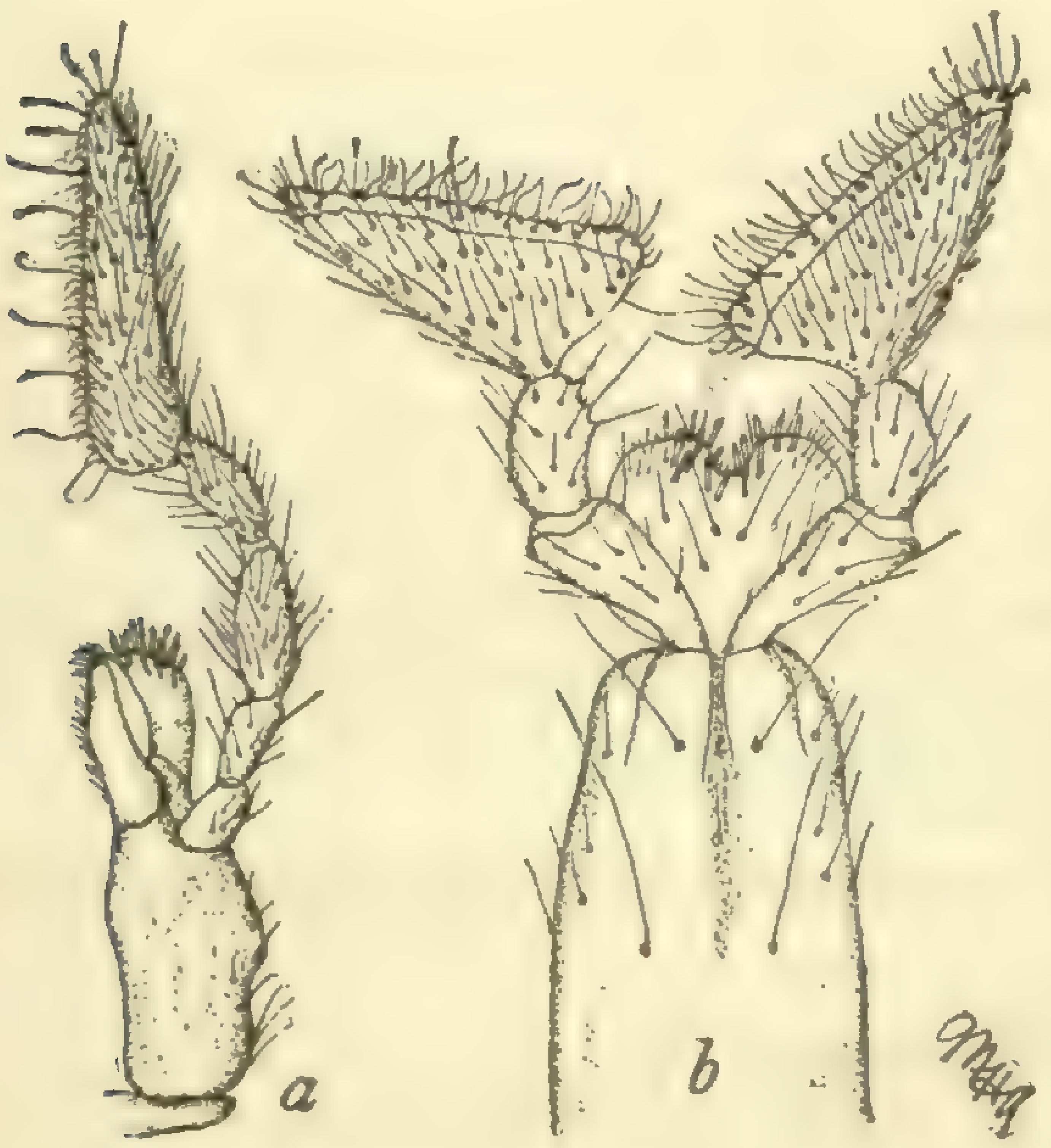

Fig. 2. — Mouth parts of adult. *a*, maxilla, × 60; *b*, labium.

but six on the lateral. Each of these is provided with a long hair. Their purpose seems to be for protection, as the floating particles retained in them make the insect look very much like a diminutive piece of aquatic vegetation. The same thing is described by Kent for Hemerobius, where the protection is furnished by the dead bodies of its victims, the aphids which are held by the long hairs. On the seventh and eighth abdominal segments there is an additional pair of hairs on shorter pedicels, near the median line. On the eighth segment there are two dorsal and two lateral projections, more elongate than those of the other segments, each of which serves as a pedicel for three hairs. The ninth has only the lateral projections. The tenth segment is everted at the end to serve as a spinneret for ejecting the silk. In sections the chitin on this part is noticeably thinner than that covering the rest of the body. Between the head and prothorax on the dorsal side is a small interpolated sclerite, mentioned by Grube, and also by Hagen in his description of Osmylus. There is no trace of it, however, on the ventral side. In Chauliodes, an insect which has the mouth parts normally directed upward rather than downward, as is the case with

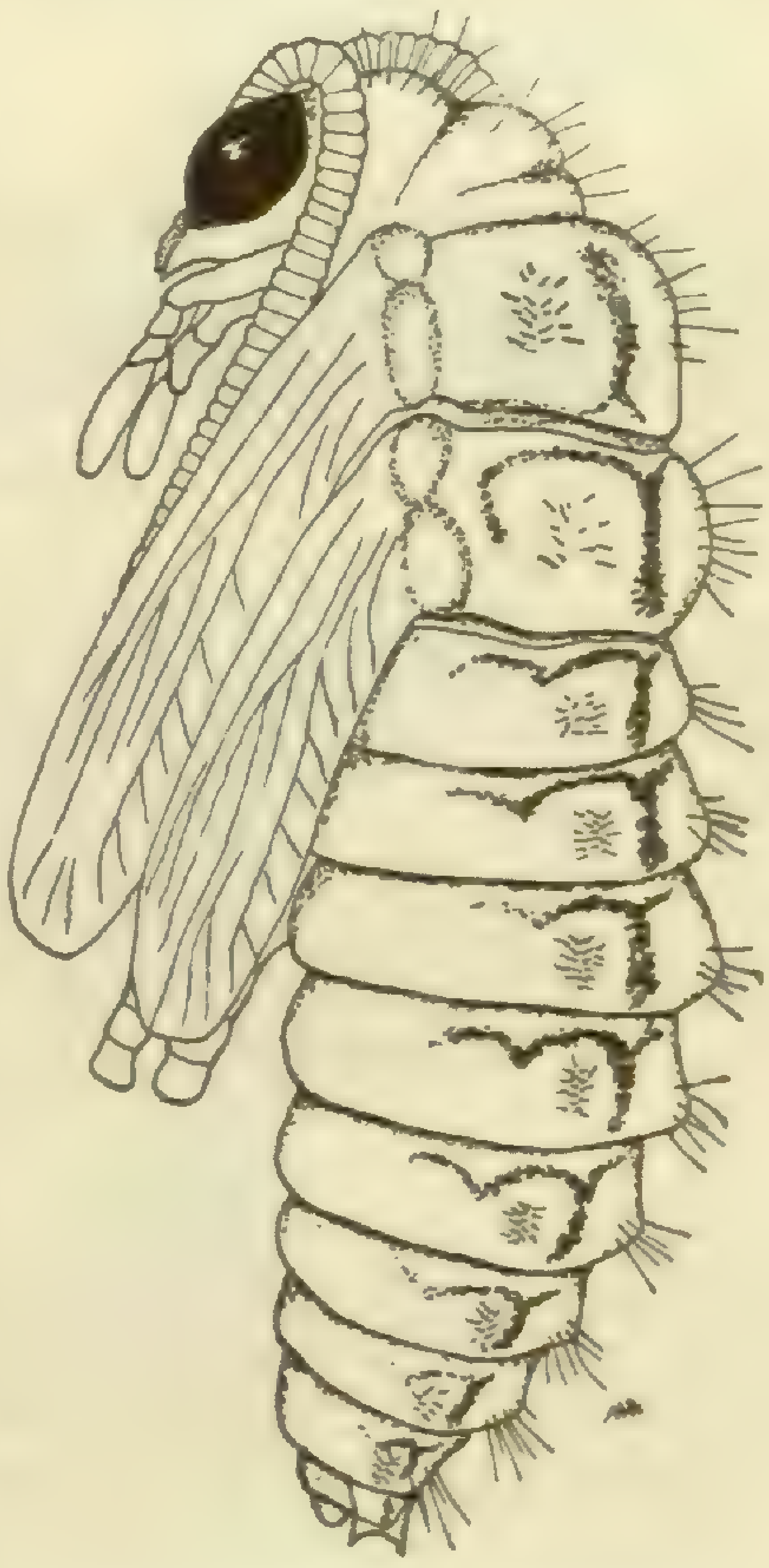

Fig. 3. — *Sisyra umbrata*, pupa. × 21.

Sisyra, there is an interpolated sclerite on the ventral side. The head has on the dorsal surface a pair of hairs directed forward, and on the ventral surface another pair similarly directed but much more elongate.

The larval respiratory apparatus consists of external gills in the form of a pair of jointed appendages on the ventral surface of the first seven abdominal segments, folded under the body so as to be unnoticeable in a dorsal view. They are moved intermittently in a rapid, shuttle-like vibration. Westwood has figured them with five joints, but I have found them uniformly to have only three. The first pair seem to have lost the articulation between the first and second joints. These have thus become two-jointed appendages.

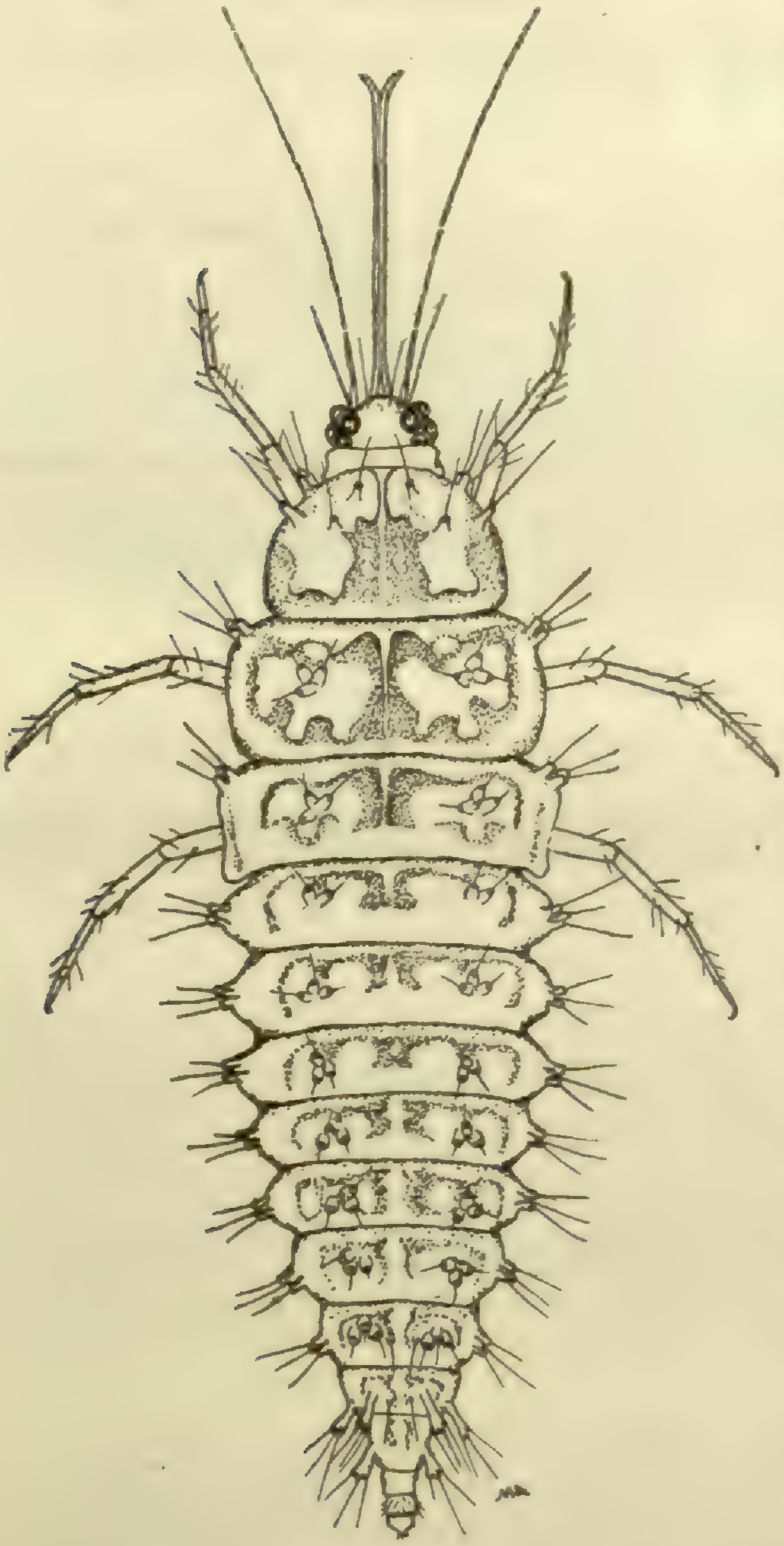

FIG. 4. — *Sisyra umbrata*, larva. × 15.

Near the point of attachment the first pair have a curious hook-like projection (*b*, Fig. 5), directed inward toward the body. This appears on the second pair merely as a knob, and gradually decreases in prominence, until it disappears almost entirely on the sixth and seventh pair (*a*, Fig. 5). On each pair of appendages except the first, at its articulation with the second joint the first one

is forked, the outer branch of the fork being longer than the inner, and both curved inward toward the body. Between these two branches the second joint is attached (*c* and *d*, Fig. 5).

The purpose of these inward-curving forks is probably to keep the respiratory filaments from too close contact with the body, and give them greater access to the currents passing through the pores of the sponge. It would seem that the first pair, having lost the fork at the terminal part of the first joint, have developed the hook-like projection nearer the base for a similar purpose. Two tracheæ can be partially traced in the alcoholic specimens, showing through the delicate outer membrane of the respiratory filaments.

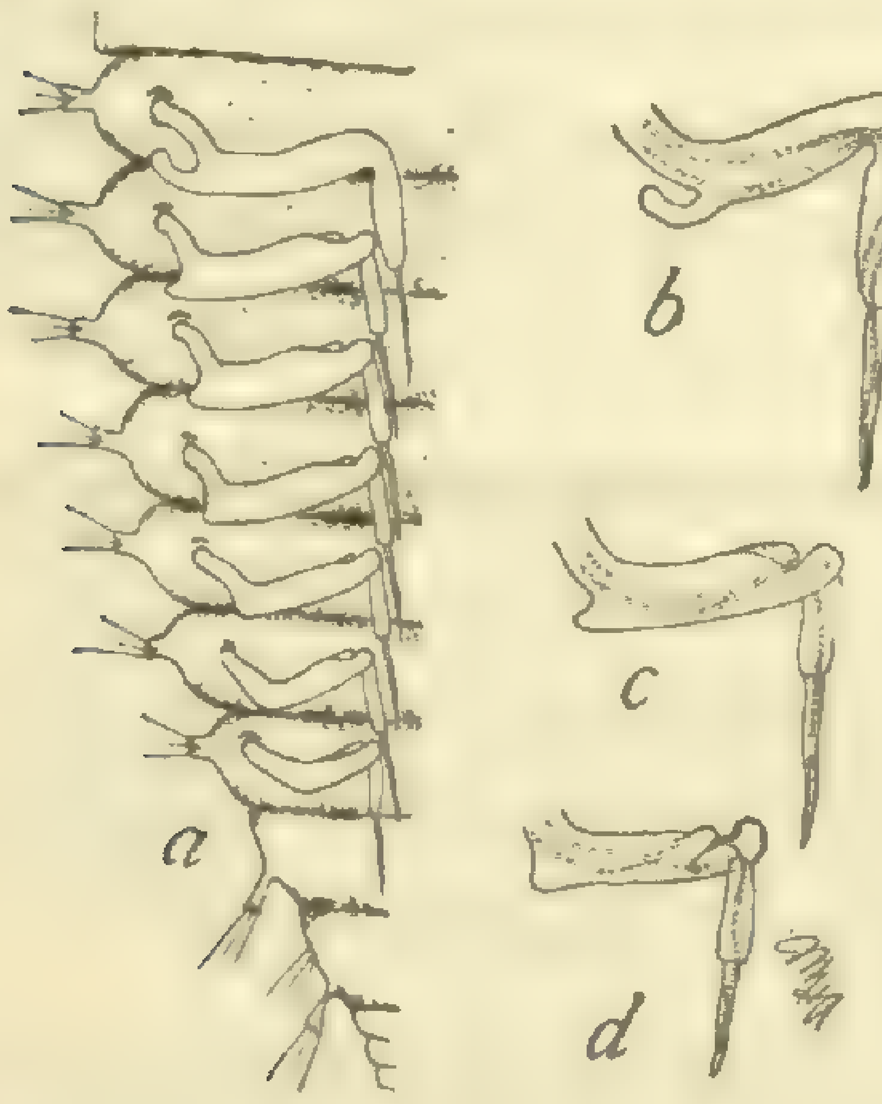

Fig. 5. — Respiratory filaments. *a*, ventral view of abdomen, × 15; *b*, left filament of first pair; *c*, left filament of third pair; *d*, right filament of fifth pair.

The mandibles and maxillæ, to fit them for piercing organs, have attained a length nearly equal to that of the antennæ (Fig. 4) and are joined to form two sucking tubes. In a cross section of these tubes (*a*, Fig. 6) the grooved edges are shown, by means of which mandible and maxilla fit each other closely. The grooved edges of both mandible and maxilla are finely serrated longitudinally, preventing them from slipping one upon another when they are used in puncturing the sponge tissue. The two readily pull apart, showing that there is no adhesion of the chitin, but that they are merely apposed. As seen in Fig. 4, these sucking tubes are conjoined for nearly their entire length, being separated only at the tip and near the base. After they enter the head they unite in a Y-shaped joint, thus forming a single tube. This Y-shaped joint can be plainly seen on the underside of the head in the chitinous shell obtained by the use of caustic potash solution. After the junction the single tube passes on

Fig. 6. — *a*, cross section of paired sucking tubes. *M*, mandible; M_1, maxilla; *b*, cross section of pharynx; *t*, tendons; *m*, m^1, points of attachment of muscles.

a nearly vertical line toward the dorsal side, where, after making a turn at right angles, it joins the œsophagus (Fig. 10).

In *b*, Fig. 6, is shown a cross section of the sucking organ (pharynx) after the point of juncture of the two tubes into one. On the anterior and posterior side it is heavily chitinized, these surfaces, together with the tendons on the anterior side, being the points of attachment for two pairs of strong muscle bands. The remaining portion of the wall of this sucking pharynx is of thin membrane. At the contraction of the muscles surrounding it, the cavity within is increased many times the size it has when the muscles are relaxed. This mechanical contrivance forms a very effective pump for drawing the juices of the sponge tissue through the sucking tubes into the œsophagus.

FIG. 7. — Antennæ. *a*, adult, × 18; *b*, larval, × 36.

The larval antenna has in most cases sixteen joints, those beyond the third being usually of equal length. The third is equal in thickness to the segments just mentioned, but equals in length the next three or four segments. The second is equal to the fourth in length, but is twice as thick. The first equals the second in thickness, but is only half as long. The eleventh is frequently somewhat shorter and the twelfth, somewhat longer than the fourth, but they are both equal to it in thickness. The thirteenth is curiously ovate, and the three terminal ones are very slender and bear one or two small spines. At the base of the ovate joint is a much longer spine. In Fig. 7 the antennæ of larva and adult are shown comparatively, but under different magnification.

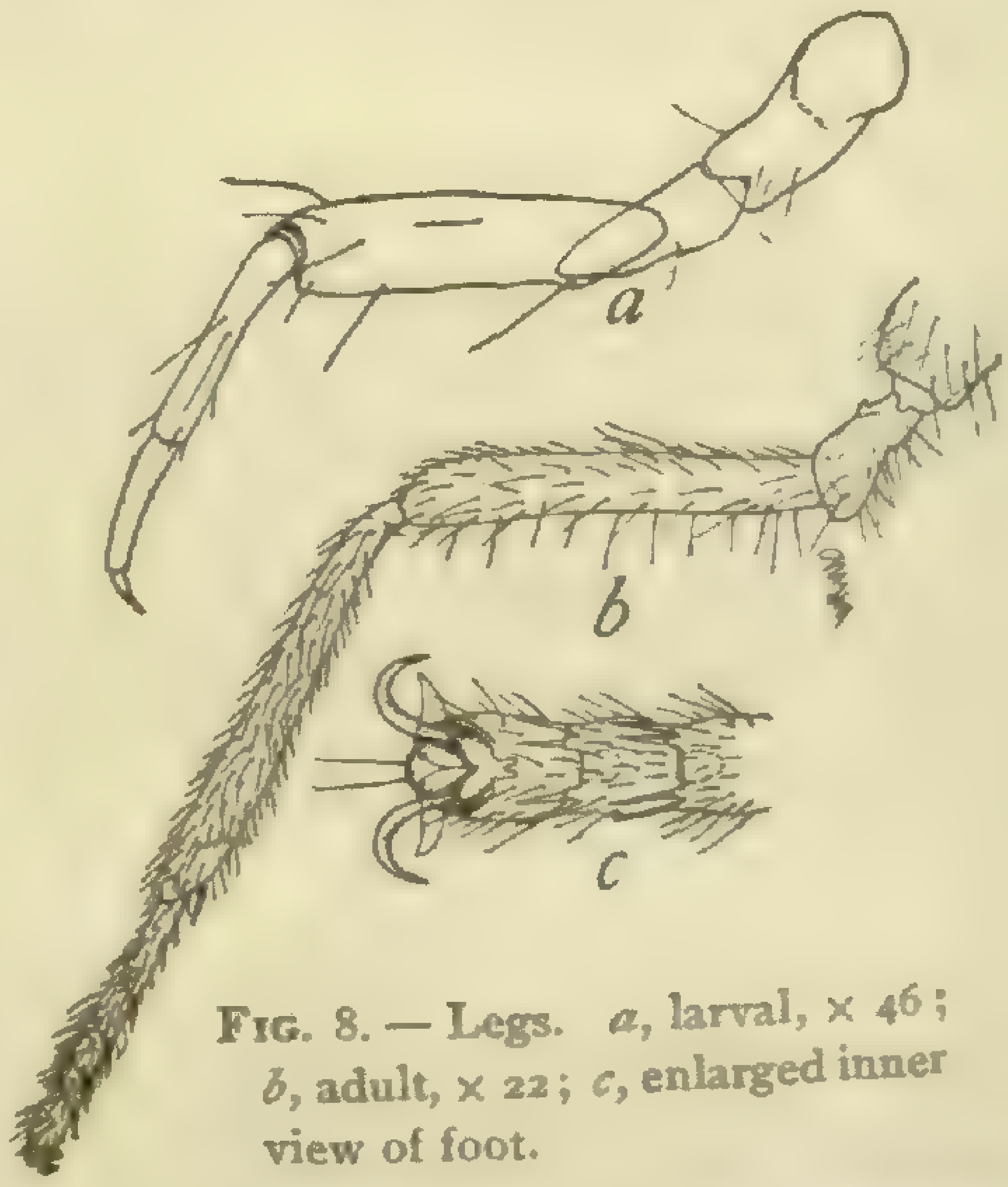

FIG. 8. — Legs. *a*, larval, × 46; *b*, adult, × 22; *c*, enlarged inner view of foot.

Fig. 8 gives a comparative view of the larval and adult leg, and a view of the lower side of the foot of the adult, showing the arrangement of claws and pulvilli, and the four large spines on the inner side of the first four joints of the tarsus. Similar spines occur on the lower end of the tibia. The larval leg has but one claw and a one-jointed tarsus. The legs of the larva are all similar. Those of the adult differ considerably; the fore legs are the shortest pair but have the coxa of unusual length, nearly equal to the tibia; in the middle leg the femur is the longest joint; in the hind leg the femur and tibia are of equal length. In all the adult legs the trochanter is much narrowed at its distal end where it articulates with the coxa.

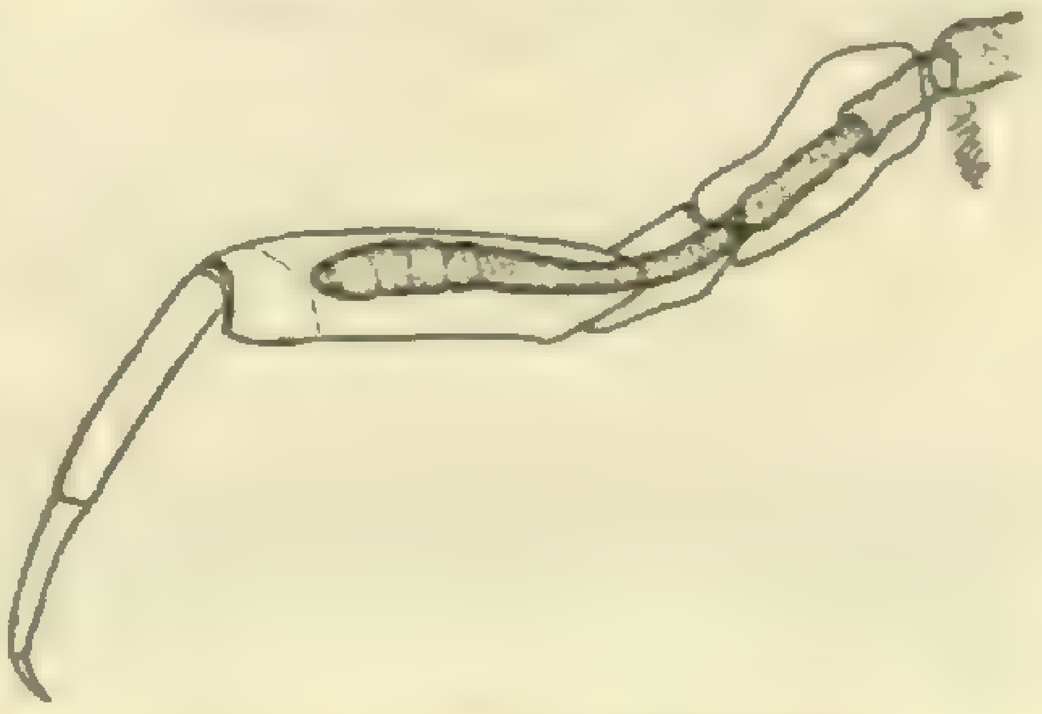
Fig. 9. — Leg transforming.

Before the pupal stage is reached, the legs pull entirely out of their chitinous covering, and the process of making over begins. In specimens lightly stained with borax carmine the adult legs can be distinctly seen developing under the old chitinous covering. This process is shown in Fig. 9, the coxa, trochanter, and femur of the adult leg being fully developed, while the tibia and tarsus with its five joints are only partially differentiated. The process of development for the antennæ and mouth parts of the adult is very similar to that of the legs, except that these adult organs, being so much larger than those of the larva, are early withdrawn entirely out of their slender chitinous sheaths, and are developed underneath the larval cuticle.

Internal Anatomy.

Fig. 10 is a diagram of a sagittal section of the larva through the median plane. The position of the brain in the prothorax has been noted in some other insects. In the very young larva the brain occupies the normal position in the head, but, as the pupal stage is approached, it gradually draws backward until it occupies the position in the thorax shown in Fig. 10. The prothorax also contains, besides its own, the subœsophageal

ganglion. The seventh abdominal segment has two ganglia, smaller than those of the prothorax but larger than the remaining eight, which are distributed — one in each of the intervening segments. The dorsal subsegment, interpolated between the prothorax and head, and which was previously mentioned, is shown here. Neither pair of the muscular bands which expand and contract the pharynx (*m*, Fig. 10), nor either of the sucking tubes below their point of juncture (*p*, Fig. 10), would be present in a section through the median plane, but I have figured them here diagrammatically for the sake of clearness.

The most difficult, and, as well, the most interesting part of this study has been the tracing of the course of the alimentary

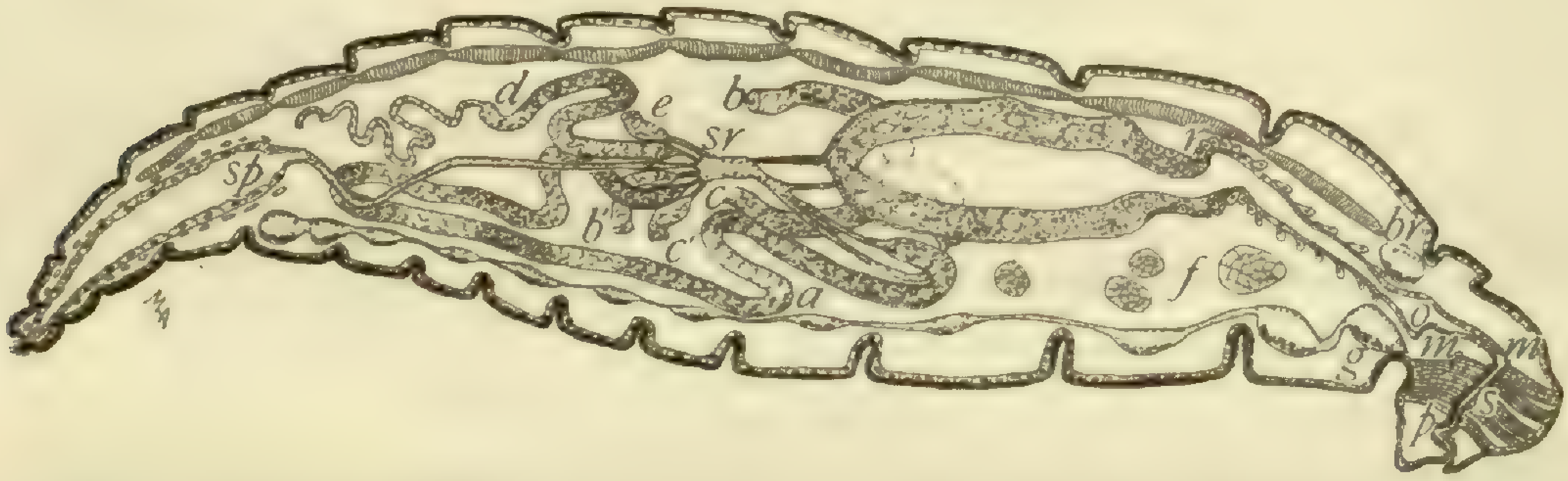

FIG. 10. — General diagram of the larva. *a*, *b–b'*, *c–c'*, three silk glands attached at both ends; *d*, *e*, two silk glands attached at one end; *sr*, silk receptacle; *sp*, spinneret; *f*, fat bodies; *br*, brain; *g*, subœsophageal ganglion; *r*, band of regenerative cells of stomach; *p*, point of junction of sucking tubes; *s*, sucking pharynx; *m*, muscle attachment of pharynx; *o*, œsophagus.

canal posteriorly from the stomach. That others have experienced like difficulties in dealing with near relatives is shown by the contradictory statements made concerning Osmylus by students of its life history (Suckow, Ramdohr, Loew, Dufour, and Hagen). I have found the work particularly difficult, as the alcoholic specimens were too brittle for dissection, and I was obliged to depend entirely upon the study of sections.

Hagen figures for Osmylus four Malpighian tubules attached at both ends to the intestine, the anterior attachment near the base of the stomach, the posterior one near the hinder end of the intestine. Three other tubules have only the anterior attachment and have their posterior end free. All of the tubules are modified in their middle portion for the secretion of silk.

Meinert found similar conditions in Myrmeleon, except that there were six tubes with the double attachment and two with free ends. He also found that there was no posterior exit from the stomach, but that the small intestine (?) had atrophied into a compact string of cells with no opening between the point of attachment of the silk-secreting tubes. The unassimilated portion of residuum is expelled as a mass after the insect has become an imago.

In Sisyra, as I have before mentioned, there is no such residuum, since the juices of the sponge are ready for complete absorption. An extensive digestive tract being in this way rendered superfluous, nature has economized by modifying a large part of the alimentary apparatus into a silk-secreting organ.

The posterior fourth of the stomach appears merely as a solid cord of atrophied cells, which ends in the walls of a dilatation, — "silk receptacle," it may be termed. The walls of this receptacle have the structure of those of the Malpighian tubules. It appears to be the outlet of five tubules, three of which are attached here at both ends, and two of which extend posteriorly and end in the body cavity. All are modified in their middle portions for the secretion of silk. The cells of the silk-secreting portion are much larger and more irregular in shape than the ordinary Malpighian tubule cells, and show the singular branched nuclei characteristic of silk gland cells in the caterpillar and other insects.

The three tubes having the double attachment proceed anteriorly to about the middle of the metathorax and are then modified at or near the point of their backward turn. Posteriorly they are modified almost immediately after leaving the silk receptacle at the base of the stomach. The two tubes having the single attachment have a considerable portion of unmodified tubule at their distal extremity, intricately coiled upon itself, as is shown by the number of variously cut sections which appear at this place in any of the three standard planes through the body. The length of the silk-secreting portion is increased by complicated coils and turns of the tubes, so that they completely fill the body cavity in the first seven abdominal segments, making it next to impossible to accurately trace

their course in sections. It seems probable, however, that there is no constancy in the nature of these coils, as the number of sections of the tubes varies greatly in different specimens. I am reasonably certain, however, of the three attached and two free tubes, as the cross sections show quite uniformly in the anterior portion of the abdomen multiples of three, and in the posterior, multiples of five. The variations from this number can be accounted for by turns in the tubes.

Connecting the silk receptable with the spinneret, which occupies the last three abdominal segments, is a tube which seems to have a straight course except for a bend ventrally in the sixth segment. This is the outlet for the silk secretion which collects first in the silk receptacle. The walls of this outlet tube have somewhat the structure of those of the Malpighian tubules, yet the cells are more regular in shape and have greater uniformity in the size and number of their nuclei. They also show, in a slight degree, the columnar nature of intestinal cells. This fact, together with the ventral bend in the course of the tube and its terminations, indicates that it is the small intestine, entirely diverted from its original function and modified so as to serve merely as an outlet for the silk secretion.

After passing through this tube, the silk collects in the spinneret, the walls of which are surrounded by bands of strong circular muscles, which aid in ejecting the secretion when the cocoon is spun.

In Fig. 10 the nature and position of the spinning glands are shown diagrammatically. The complete course of one of the three which are attached at both ends, and of one of the two which are attached at one end, is figured.

Fig. 11 shows longitudinal and cross sections of the silk glands with their fantastically formed nuclei. The typical structure of the Malpighian tubule is also shown and its gradual modification into silk-secreting cells. In *a*, Fig. 11, a section of a functional silk gland is shown, the walls being much thinner and the nuclei of simpler forms than in *b* of the same figure, where no secretion is visible. Some of the sections figured show traces of vacuolization, a common sign of the

degeneration which is characteristic of the first stage of metamorphosis. Sections of older larvæ show the silk glands in a much more advanced stage of degeneration, and numerous leucocytes in their vicinity or clinging to their walls. In the pupæ there are only a few fragments of the larval silk glands, but adult Malpighian tubules are seen forming, for which the material from the degenerated silk glands is probably again used.

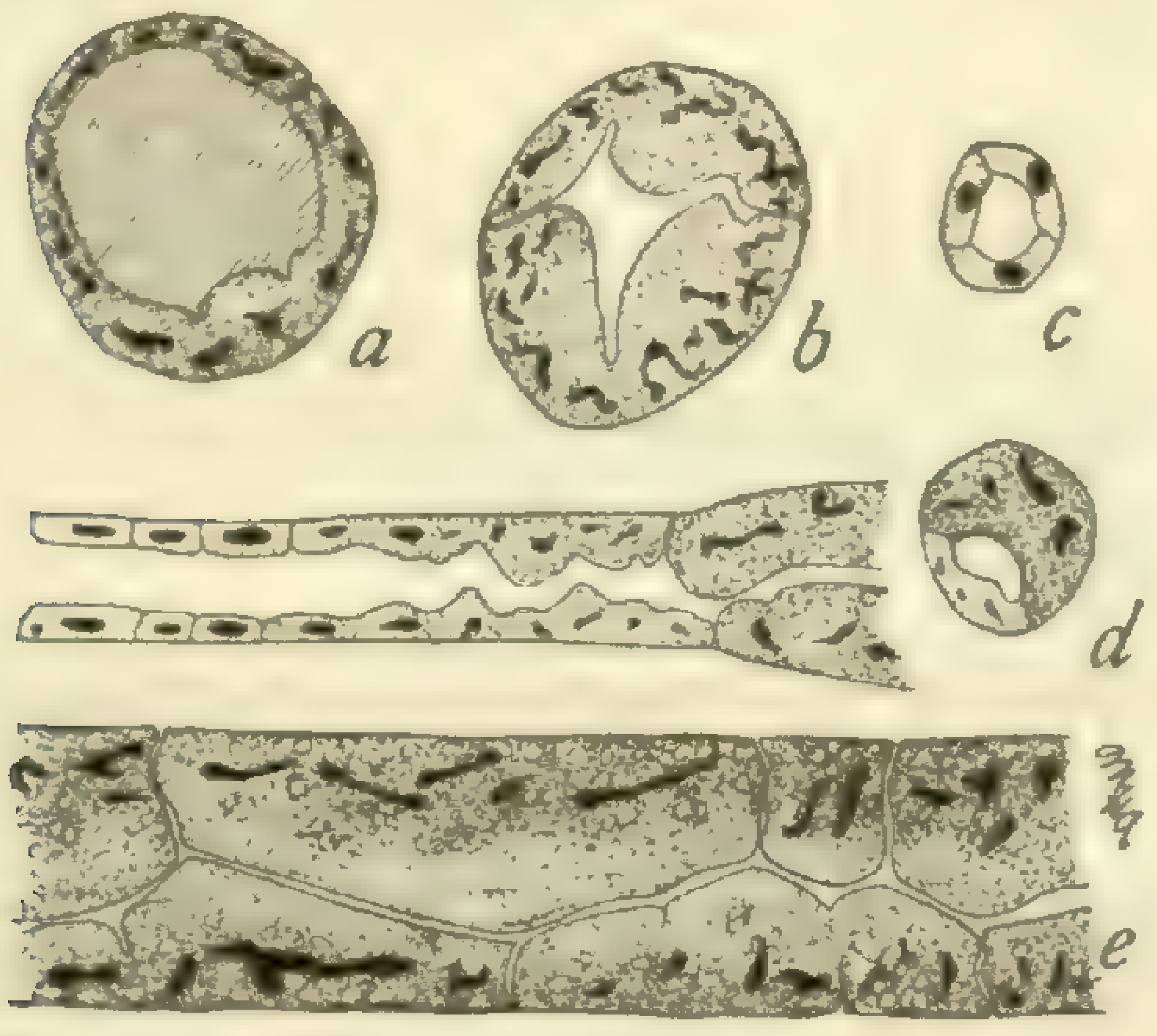

FIG. 11. — Silk gland sections. *a*, cross section of functional gland; *b*, cross section of gland without secretion; *c*, cross section of unmodified tubule; *d*, section showing gradual modification into silk-secreting cells; *e*, longitudinal section of silk gland, showing vacuolization.

Digestive Epithelium.— Sections through the digestive epithelium of a normal, feeding larva show vacuolization, even at this early stage At the anterior end of the stomach is a circular band of small cells which remain active and functional during the period of degeneration of the other epithelium. In the process of degeneration all traces of cell boundaries disappear, in some places the cell substance being a liquid mass in which float the nuclei. The disintegrated epithelium is finally cast off from the walls into the center of the cavity and the new rapidly grows out from the regenerative band to take its place, new nests of regenerative cells appearing at frequent intervals. It would seem that the solid cord of cells at the posterior end of the stomach serves as another regenerative center, since at this stage there is an opening from this end of the stomach through what was the solid cord in the larva. The adult intestine seems to be developing from the cells at this point as a regenerative center. The adult Malpighian tubules are probably also developed in part from these cells. I have seen clear evidences of a new set of these organs forming in the normal position at the base of the stomach.

FIG. 12.—Larval wing. *h*, hypodermis; *p*, peripodal membrane; *t*, trachea; *w*, wing.

DEVELOPMENT OF THE WING.

Some time before the larva spins its cocoon the wing buds begin to appear, showing through the thin skin. These form a very convenient index of the age of the larvæ. Fig. 12 represents a longitudinal section through a wing bud at an

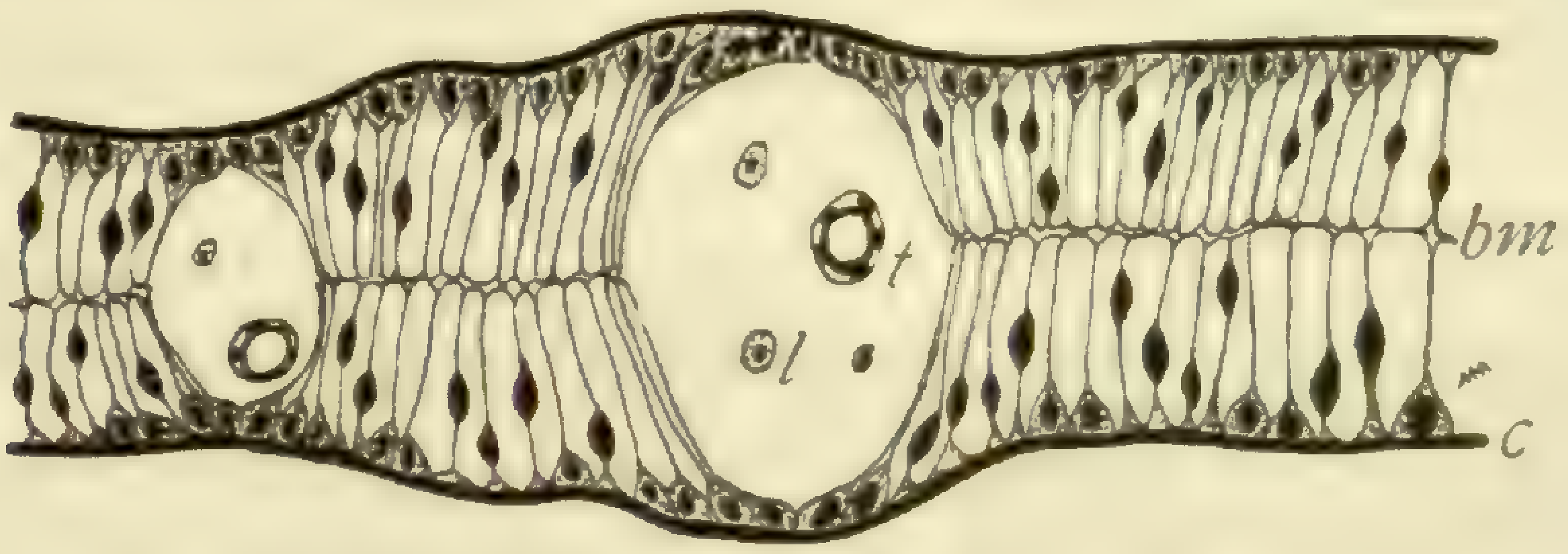

FIG. 13. — Section of older wing. *bm*, basement membrane; *c*, cuticle; *t*, trachea; *l*, leucocytes.

early stage, before it is clearly visible from the outside. The two layers of closely packed cells have not yet united. The first formation of the tracheæ is also shown.

The next stage figured is much later, when the two layers have united, leaving large openings through which pass the tracheæ, now fully developed (Fig. 13). Leucocytes are found frequently in these openings. The great stretching of the wing tissue by its growth both longitudinally and laterally has drawn the upper part of the cells into slender processes, all of

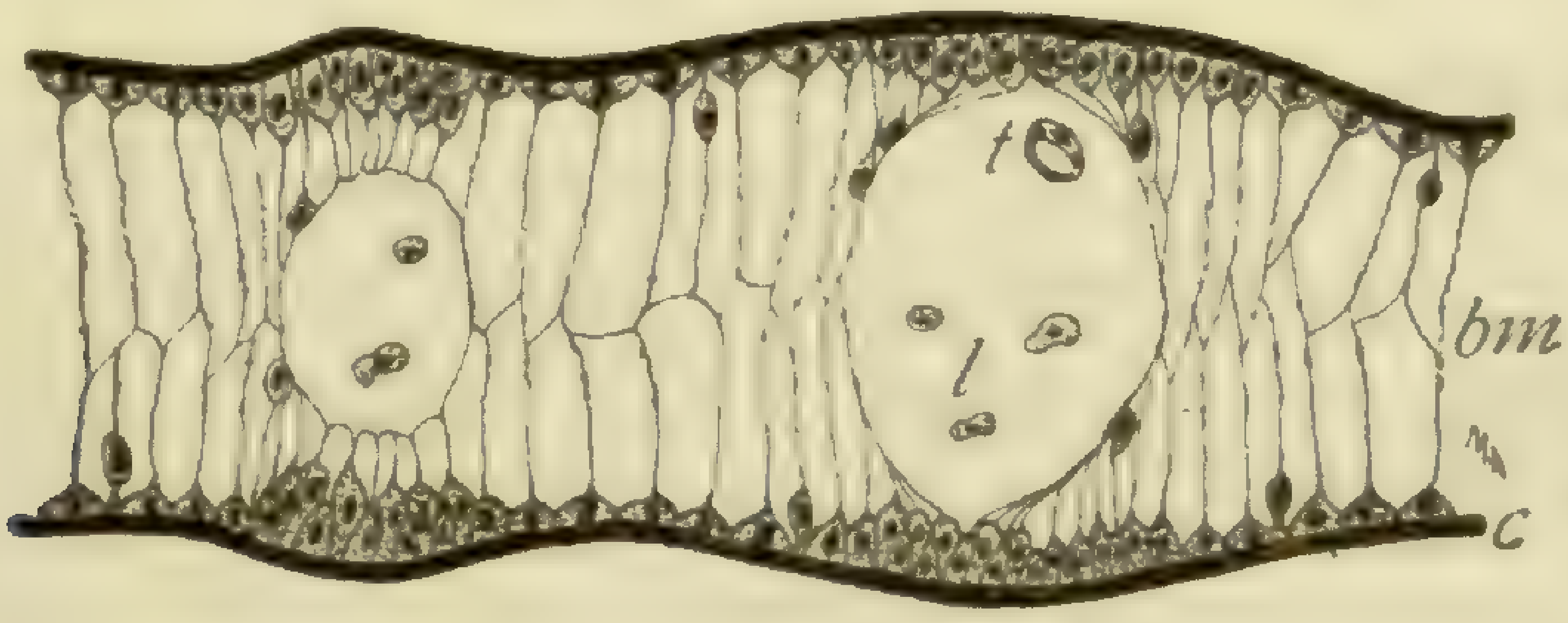

FIG. 14. — Section of older larval wing. *bm*, basement membrane; *c*, cuticle; *t*, trachea; *l*, leucocytes.

which join the basement membrane, separating the two cell layers. Many of the nuclei have been drawn up by the strain from their normal position along the layer of chitin, so that in some cases they nearly touch the basement membrane. The subsequent growth of the wing is nearly all in a longitudinal direction.

Fig. 14 shows the effect of a greater stretching in a longitudinal direction. Most of the nuclei have returned to their position next the cuticle. A very few have progressed too far for return, and are left clinging to the tracheal openings or standing alone and apart from their fellows. The cell processes are much more ragged and broken than in the last stage, and the basement membrane is pulled out of its straight line, being very uneven and irregular. Traces of the old connection may be seen, however, in the slight thickenings in the cell processes. Along the tracheal openings where the adult veins are to be, we see preparation going on for the task of depositing extra layers of chitin. At these points the cells become aggregated in two or more apparent layers and have larger nuclei.

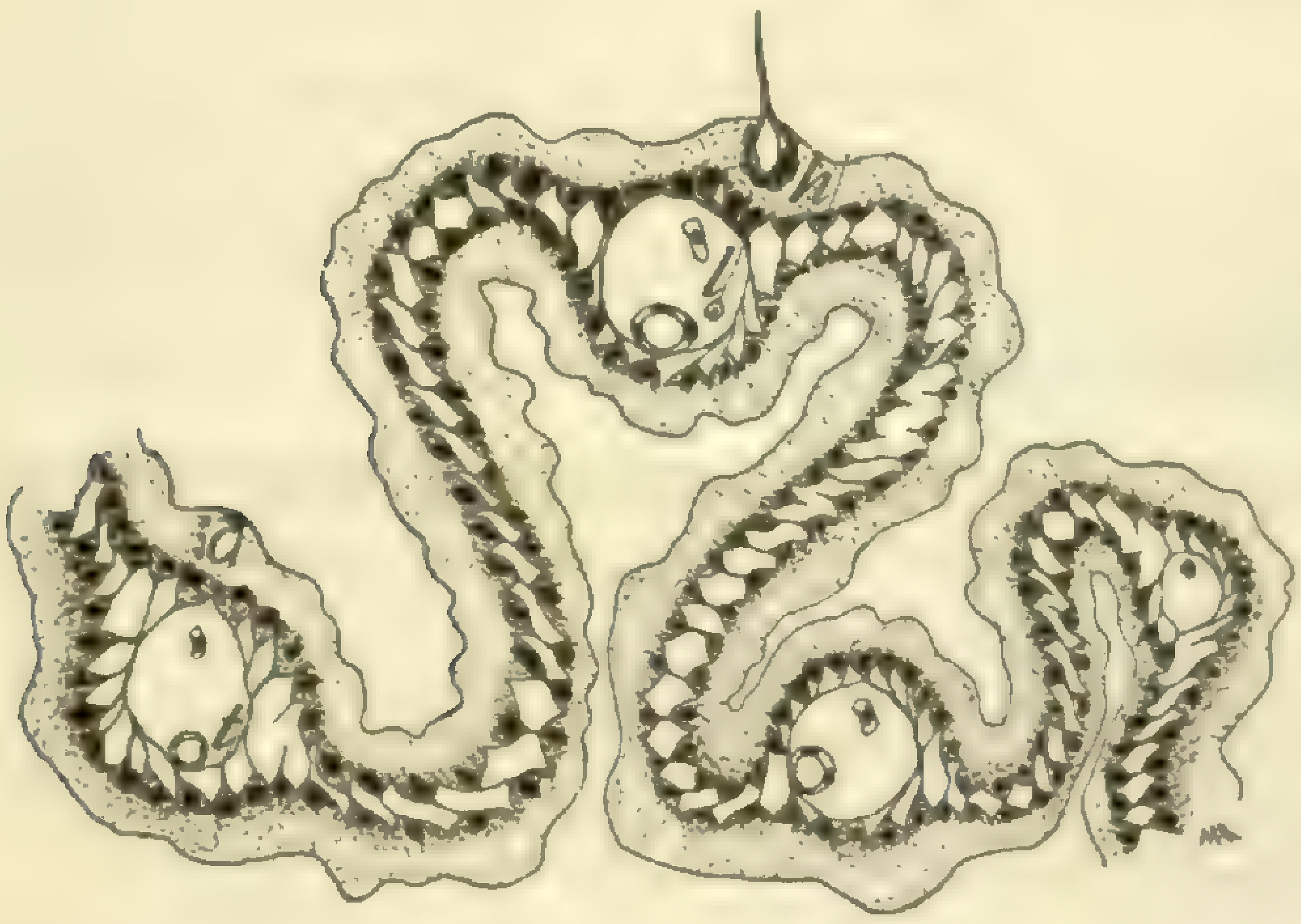

FIG. 15. — Pupal wing. *c*, rudimentary chitin; *h*, mother cell of hair; *l*, leucocytes; *t*, trachea.

The next section figured is from the wing of a pupa (Fig. 15). Here the wing has increased greatly in length and decreased in thickness. The slender cell processes have almost entirely disappeared, all the cells are on one level and have secreted a thick layer of material, which, after the final molt, will harden into chitin. Owing to the close quarters within the pupal skin, the wing has become extensively fluted and crinkled to permit the now rapid growth longitudinally. In Fig. 15 a hair cell is shown developing in the cuticle, — a large vacuolated mother cell, with nucleus at one side and small cells clustered about it.

FIG. 16. — Sections of adult wing. *a*, soon after molting; *b*, older. *t*, trachea; *h*, mother cell of hair; *l*, leucocytes.

The next stage shown is from a recently transformed adult (*a*, Fig. 16). The crinkling has disappeared, leaving the wing nearly flat. The processes are contracted within the cell body, drawing the chitinous layers close together. Near the tracheæ are shown the fully developed hair bulbs. The tracheal openings and spaces between the cells show numerous leucocytes, and all the hypodermis is engaged in the work of thickening the chitinous covering.

In *b*, Fig. 16, a section of an older wing is represented. The upper chitinous layer has become much thickened and the only traces of cells are the occasional nuclei and the thin line

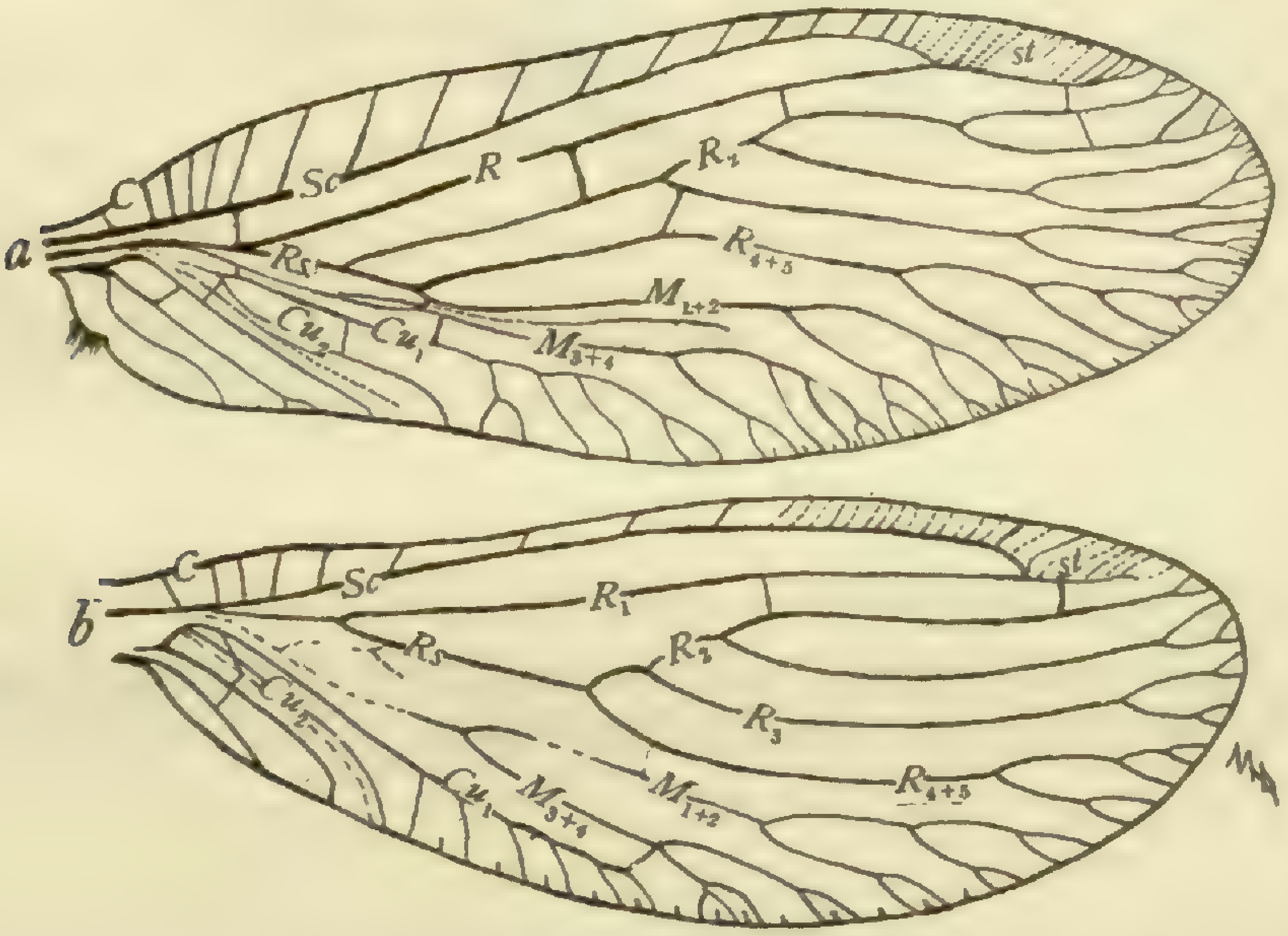

FIG. 17.—Wings of adult, × 15. *a*, fore wing; *b*, hind wing.

of protoplasm between the chitinous layers. In the wings of some insects nothing but the chitinous plates persist, but Sisyra seems to retain throughout this slight vestige of cellular tissue.

Fig. 17 shows the venation of the fore and hind wing of Sisyra. It is rather simple for this family. There are few cross veins. The course of the principal veins may be easily followed. There is, however, quite an extensive variation in the tips of the main branches. A study of this variation should throw some light on the method of evolution of the peculiar hemerobian type. I have tabulated the extent and nature of the variation in fifty wings. Fig. 18 shows the type of branching of the principal

veins, as far out as the point where they cease to be uniform, and the ten different forms of tips appended to these branches, found in the specimens studied. The branches of R_2, R_3, etc., are lettered (*a*, *b*, *c*, etc., Fig. 18), and the different types of tips numbered (1–10, Fig. 18) to correspond with the letters and numbers of the table. The variants and their frequencies are shown for each lettered tip in the table; *e.g.*, tip No. 7 — the most common type — occurs, in the fore wing, four times on branch *a*, sixteen times on branch *b*, etc.

	FORE WING.										HIND WING.									
	LEFT.					SYMMETRICAL.				RIGHT.	LEFT.					SYMMETRICAL.				RIGHT.
	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10
a					3		4	14	1	3					2	2	18			3
b					3	2	16			4						5	20			
c						14	11									21	4			
d						5	19			1						23	2			
e					6	2	17									1	24			
f					1		22			2						4	21			
g					1		24								1	11	13			
h						7	18									14	11			
i						12	12	1								22	3			
j						11	13			1						19	6			
k				2	12			9		2					17		1	5		2
l					9		7	5		4					7		13	1		4
m					9		7	5		4					5		20			
n					11		7			7					2		22			1
o				4	16		1	4			2	7	14		2					
p						4	21									25				

From a glance at the table and Fig. 18 one sees the tendency is toward extensive multiplication of symmetrical branches on R_2, and that back of R_5 the branching becomes increasingly asymmetrical toward the left, this asymmetry culminating in Cu_1, especially in the hind wing. No variation in the cross veins of the hind wing was observed in the twenty-five specimens examined, and only a slight variation in those of the fore wing. In every case the variations noticed were in the disk of the wing, except that in two cases there was a cross vein between the first pair of secondary branches of R_2

(*a*, *b*, Fig. 18). Such a case is shown in Fig. 17. The cross vein in the basal part of the subcostal space, said by some to be absent in Sisyra, was present in every specimen. The other variations seen were in the number of cross veins between R_1 and R_2, which is normally three. In two cases four were present and in one other instance there were five. But these were all of a nature easily explainable, as there were two or three faint veins standing close together, showing that the material usually forming one vein had formed several. Between R_2 and R_3, the only other space showing any variation, the

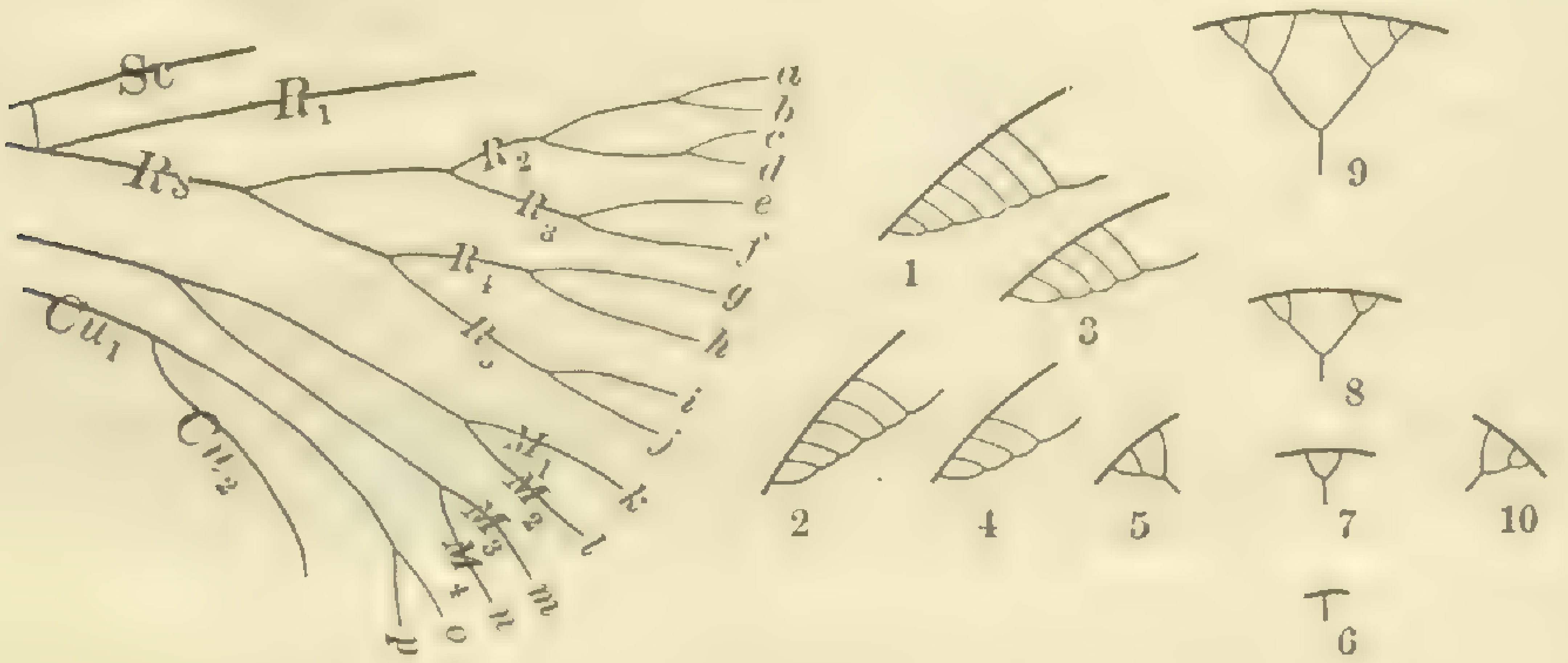

FIG. 18. — Diagram of variation in wing veins, illustrating the table.

normal number is one. In seven cases there were two, in one three, and in one four. The same tendency to have several weak veins close together was shown here. All the added cross veins were on the proximal side of the normal one. The variation in cross veins seems to have no connection with that in the tips. The specimen having the most erratic form of tip (9, Fig. 18), which occurred only once, had the cross veins entirely normal.

SUMMARY.

The points of chief interest developing from this study may be summarized as follows :

1. In Sisyra the mouth parts are not in the usual opposed position, but are approximated in pairs to form two sucking tubes, excessively elongated, and decurved.
2. The brain is in the prothorax in old larvæ.
3. The stomach has no posterior opening in the larva.

4. Three Malpighian tubules are attached at both ends, and two are attached at one end, — all metamorphosed into silk glands in their middle portion.

5. The small intestine is modified into an outlet for the silk secretion.

6. The spinneret is formed from the terminal part of the alimentary canal.

7. A completer account than has hitherto appeared is here given of the late stages of wing development, and the variations in venation of fifty wings are tabulated.

Biological Laboratory, Lake Forest College.

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THE REGENERATION OF THE PHARYNX IN PLANARIA MACULATA.

HENRIETTA F. THACHER.

In a paper on *Planaria maculata*, published in 1898, Morgan called attention to an important feature of the regeneration of the pharynx, namely, that in regenerating pieces which were cut anterior to the old pharynx, the new pharynx forms "at the edge of the old tissue, but lying for the most part within the *new* material," while if the cut were made posterior to the pharynx the new organ forms in the anterior end of the *old* tissue. During the next two years there appeared a number of papers describing experiments on the power of regeneration in planarians, but giving no further knowledge of the development of the pharynx except that to be derived from general statements of the various positions it may assume in the regenerating pieces. More recently a paper by Bardeen on the physiology of *Planaria maculata* has taken up the formation of the pharynx in this species and given a somewhat detailed account of it.

In studying the origin and growth of the new pharynx, I wished to find out if there were any marked difference between its formation in the *new* tissue of the anterior piece and in the old tissue of the posterior piece, since the conditions for regeneration seemed so unlike in the two cases. At the same time I was interested in observing in the posterior pieces what might be the influence of the reproductive organs when present in the region where we should expect the pharynx to appear, and if, under these conditions, the already existing cavities and external opening can be made use of. In this connection I examined series of regenerating posterior pieces in which the cut had been made (1) just posterior to the pharynx, but at a time of year when the reproductive organs have disappeared; (2) anterior to these organs when they are fully developed; and (3) posterior to them.

The greater part of the material for my experiments was collected from ponds near Woods Hole during the months of June, July, and August, and was preserved for study in the following winter. Later in the year more planarians were found near Bryn Mawr, and were kept in aquaria until needed. Each worm was cut into three pieces, of which the middle, containing the pharynx, was rejected, and the anterior and posterior pieces were allowed to regenerate. The latter were killed at intervals of twelve hours for about eight days, at the end of which time those remaining had begun to feed. Where it seemed advisable, series were killed at closer intervals, but as a rule this was not necessary. The pieces remained in corrosive acetic for about ten minutes; after cutting they were stained on the slide in Delafield's hæmatoxylin, and then dipped for a few seconds into a strong solution of aniline orange. The latter differentiates the endoderm, muscle bands, yolk cells, and the lining of the reproductive system.

Soon after the worms are cut, the edges of the cut-end draw together and matter from the digestive tract and loose parenchyma tissue collect about the injured region. Within a few hours the surface opens out again, until only a slight depression marked by a dark line of pigment is noticeable. In the mean time parenchyma cells collect at the cut surface and form a narrow sheet across it, while cells from the margin of the uninjured epithelium push out and cover the new growth. This overgrowth of epithelium is comparatively rapid, as the cells in this region flatten out and cover individually a much larger area. By the end of the first day the tip has become rounded and the anterior end is covered with an epithelial layer; later, with the increase in their number, the flattened cells resume their columnar form.

The parenchyma of the normal planarian appears on examination as an ill-defined mass filling in the spaces between the organs. Its protoplasm stains very slightly, but the tissue is conspicuous owing to the many deeply colored nuclei that are present in it. These nuclei are occasionally seen in small groups, but they are usually scattered and separated from each other by the loose spongy tissue. Among the parenchyma

cells are found other cells which are specialized in function,—large rhabdite cells, lying just below the ectoderm and showing the rhabdites buried in the protoplasm, and the mucous cells, staining an intense blue; also, along the digestive tract, a few large granular cells for which Bardeen has suggested a digestive function. In addition, I have noticed some large cells staining with aniline orange, which seem to contain some such material as yolk. Whether this is a fourth kind or merely the digestive cells I have not been able to decide. There are also present elongated connective-tissue cells.

Although the majority of the parenchyma cells show little protoplasm, scattered through the tissue of the normal uninjured animal there are a good many cells whose nuclei resemble those of the ordinary parenchyma, but which have gathered about them an irregular mass of granular protoplasm. As many of these are in various stages of division, while I have found no division among the cells with less protoplasm, it is probable that the accretion of protoplasm is the usual forerunner of division in the parenchyma cells, and that the number of the latter is constantly increasing even in normal planarians. While the number of these dividing cells differs individually, they are often very numerous and are confined to no one region of the body, except that they are more rare in the extreme tips. The dividing cells stand out very distinctly as they are larger and seldom have other cells near them.

After the animals are cut, the amount of division increases somewhat throughout the whole body, but very markedly near the injured surface. Cells also migrate down into this region and form there a thickening which rapidly enlarges. That migration takes place is indicated by the long trails of protoplasm that give to the cells a bipolar appearance with the axes directed towards the growing mass (Fig. 1), while in the normal planarian there is no such effect and the cells are more irregular and rounded in outline. After the thickening has reached a certain degree of concentration there is rarely any cell division in the proliferated mass, but mitotic figures can frequently be found in the region near by, where the cell mass is less dense. Cells also continue to migrate into the new part and

add to the new growth. The number of cells in the parenchymatous tissue of the body itself is also usually much increased as the nuclei throughout continue dividing, and by the time the pharynx thickening appears, which is in the course of the third day, the tissue is filled with cells conspicuous on account of their greater amount of protoplasm.

I shall consider first the growth of the pharynx in the anterior piece and then that in the posterior piece. By the time the proliferation of cells in the regenerating posterior tip is quite marked, a slight shift in the direction taken by some of the cells denotes the beginning of the new pharynx. The cells now collect just on the line between the old and new tissue at the posterior end of the digestive tract, which has rounded off, and usually has begun to bud out side branches. As is true of the growing end, so here, when the thickening becomes marked, no division of cells can be found in it, but in the less dense tissue around it there are many dividing cells and apparently considerable cell migration towards the new growth. The collection of cells stains very deeply in comparison with the old tissue near by, due probably to the greater amount of protoplasm in this region.

The thickening for the pharynx grows until it is quite large, and then the split for the pharynx chamber begins. This opens up very rapidly as a narrow cavity running across the base of the thickening and up on the sides, being usually more advanced on the ventral than on the dorsal side. It is at first irregular in outline, but the cells along the edge soon flatten out into a thin lining epithelium. As development proceeds, cells are added at the anterior end of the new pharynx, while there is no division in the compact mass of cells already collected (Fig. 2). About the fourth day the lumen of the pharynx itself appears in the center of the proliferation, due to an elongation and pulling apart of cells which become larger and thin walled and form the lining of the pharynx. This cavity gradually enlarges posteriorly to open into the pharynx chamber, and anteriorly to unite with the wall of the digestive tract, which then breaks through to join with it. The new region has in the mean time steadily increased in

length, and the branches of the intestine have pushed back into it, while the central digestive cavity has also somewhat enlarged. Shortly after the lining of the lumen has formed, the muscle bands of the pharynx differentiate. They arise from cells just between the two epithelial layers; they elongate and undergo some change in their constitution, since they stain with aniline orange very shortly after the lengthening process has begun. The change is first visible in the region where the pharynx is continuous with the body of the animal

FIG. 2.

FIG. 1.

FIG. 3.

FIG. 1. — Large parenchyma cells migrating towards regenerating region.

FIG. 2. — Pharynx in anterior piece at close of fourth day. The lumen has just appeared. *A*, lumen; *B*, lateral digestive branch; *C*, pharynx chamber.

FIG. 3. — Pharynx in posterior piece at close of third day. The lateral digestive branches have met, and the pharynx thickening (*A*) is conspicuous. There are many dividing cells present.

and extends gradually posteriorly. So far as I could determine, the circular muscles develop before the longitudinal, but if so, the difference in time is very slight. In the course of the fifth or sixth day the pharyngeal chamber opens to the exterior by an ectodermal invagination from the ventral surface, and shortly afterwards the animal begins to feed.

The shape and size of the pharynx vary comparatively little after the inner lumen appears. At first, before the formation of this cavity, the shape is slightly pointed, but it soon becomes more regular and assumes the form of the normal pharynx, except for its length, which is only about once and a half or twice the breadth. The addition of cells at the anterior end

does not continue after the structure is well organized, and the latter part of the time needed for the regeneration of this organ is occupied in changing the parenchyma cells into the different tissues. Up to the time when the muscles appear, the cells still remain crowded together and show by their deep color the presence of unusually dense protoplasm. After the muscles are well formed the tissue assumes a less dense appearance, and this change arises apparently at the same time in the cells throughout the new tissue. Deeply staining masses, as of mucous, can also be seen, so that the tissue soon resembles that of the normal worm.

The process of formation of a new pharynx in the old tissue of the posterior piece seems to be very similar, and equally simple during the nine months of the year when the reproductive organs are absent. The overgrowth of the cut surface and the increase in the number of dividing cells is just as was found in the anterior piece. The pharynx thickening, however, appears about twelve hours later than in the former case, *i.e.*, about the end of the third day, and is usually noticeable shortly after the two branches of the digestive tract have joined. But that the pharynx is formed with relation to the "axial gut," as Bardeen states, I am not prepared to say, as occasionally a case is found in which the branches have not met, although a thickening is present, and often in a slide showing a conspicuous gathering of cells the union between the intestines has barely taken place. The pharynx forms a short distance posterior to the cut, in the old tissue. It is first made visible by the shifting of the axes of some of the cells, which now direct themselves toward the new point of activity, and the thickening increases rapidly (Fig. 3). The cavities open up just as in the anterior piece, but the chamber is apt to be much longer and more irregular in outline than in the other case. Later the enlarged cavity rounds off so that the chamber resumes its normal size. The central cavity of the digestive tract enlarges in a posterior direction, and at the same time the pharynx thickening is added to by cells at the anterior end; thus, by the time the pharynx is ready to open up, the original space between it and the

digestive tract is bridged over (Figs. 4, 5). The appearance and development of the lumen, muscle bands, and normal spongy tissue is identical with that in the anterior pieces, and the posterior piece is also ready to feed in seven days.

Summing up these results, it appears that the regeneration of the pharynx in the new and in the old tissue is much the same, (1) as to the origin and migration of the cells, (2) as to the formation of the two cavities (the chamber and the lumen of the pharynx), and (3) as to the differentiation of the cells into the normal tissues. They differ (1) in the length of time that elapses before the pharynx thickening shows itself (about twelve hours more being required for its appearance in the old tissue than in the new), (2) in the position of the developing

FIG. 4.

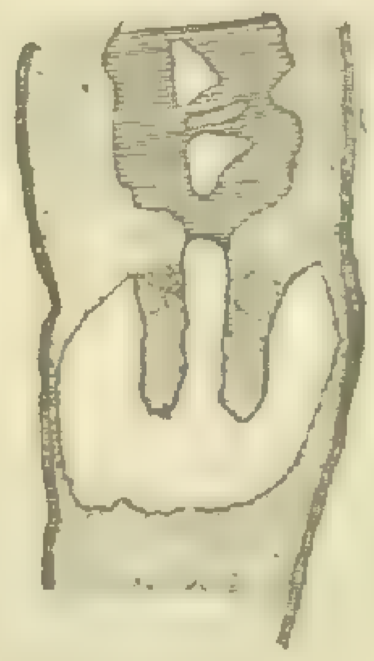

FIG. 5.

FIGS. 4, 5. — Stages in development of pharynx in posterior piece.

pharynx with regard to the central digestive cavity, and (3) in the size of the pharyngeal chamber as shown by its early irregularities in the posterior piece. The last two differences are probably due to the disposition of the digestive branches in the two cases.

In the early part of the summer the reproductive organs of this species are fully developed, and regeneration under these conditions is especially interesting. The genital apparatus lies for the most part in the region just between the pharyngeal and genital pores, so that when an animal is cut just posterior to the pharynx these organs occupy the region where the new pharynx should develop. Under these conditions there is no sign of the growth for the new pharynx until towards the end of the fourth day, when a small collection of cells can

be found in a ventral but not necessarily median position. Also this mass is usually at a normal distance from the fused intestine. Morgan (1900) has noted this delay in the formation of the pharynx when the worm is cut anterior to the genital pore at this time of year (July 2) and finds about twelve days instead of seven required for complete regeneration. His later experiments, begun July 31, gave different results, but this was probably due to the degeneration of the reproductive organs between these two dates, as he found that the time required for this set of pieces to become complete animals was only seven days.

This delay may be due to the scarcity of parenchyma cells in this region, which is almost completely filled by the tissue of the genital organs. When these organs are fully present the parenchyma cells collect as shown in Fig. 6, migrating principally from the anterior end into the region of parenchymatous tissue that lies just ventral to the penis. In this drawing are shown in the tissue along the edge of the genital organs certain irregular breaks that seem to appear at the beginning of the degeneration of these structures. The pharynx forms ventral to such cavities, and the split for the pharynx chamber is at first entirely independent of them (Figs. 6, 7). Later the wall between may break down, and thus greatly enlarge the chamber, but if so it is a secondary process; there is also a tendency towards degeneration in the thin line of tissue between the pharynx and reproductive chambers, as shown by the dotted line in Fig. 7. In no case, however, does the old genital pore become the new pharyngeal pore.

As the genital organs degenerate, which I have found takes place during the last two weeks in July and the beginning of August, the region in which the pharynx appears becomes quite irregular. The only feature that seems at all constant is the relative distance between the cross-branch of the intestine and the pharynx thickening. That this is true may be seen by a study of its position with relation to that of the genital pore. The main genital duct opening to the exterior persists longer than any other part of these structures, but its presence

seems to have little or no influence on the position of the new pharynx. The latter may appear far anterior to it, posterior, or, as in Fig. 8, it may assume an eccentric position and lie on the same level; in this case the duct and pore are shown by dotted lines, as the pharynx lies about eight sections to the side of the median line, *i.e.*, of the genital pore. Thus the new pharynx can be found in all possible positions, and the varia-

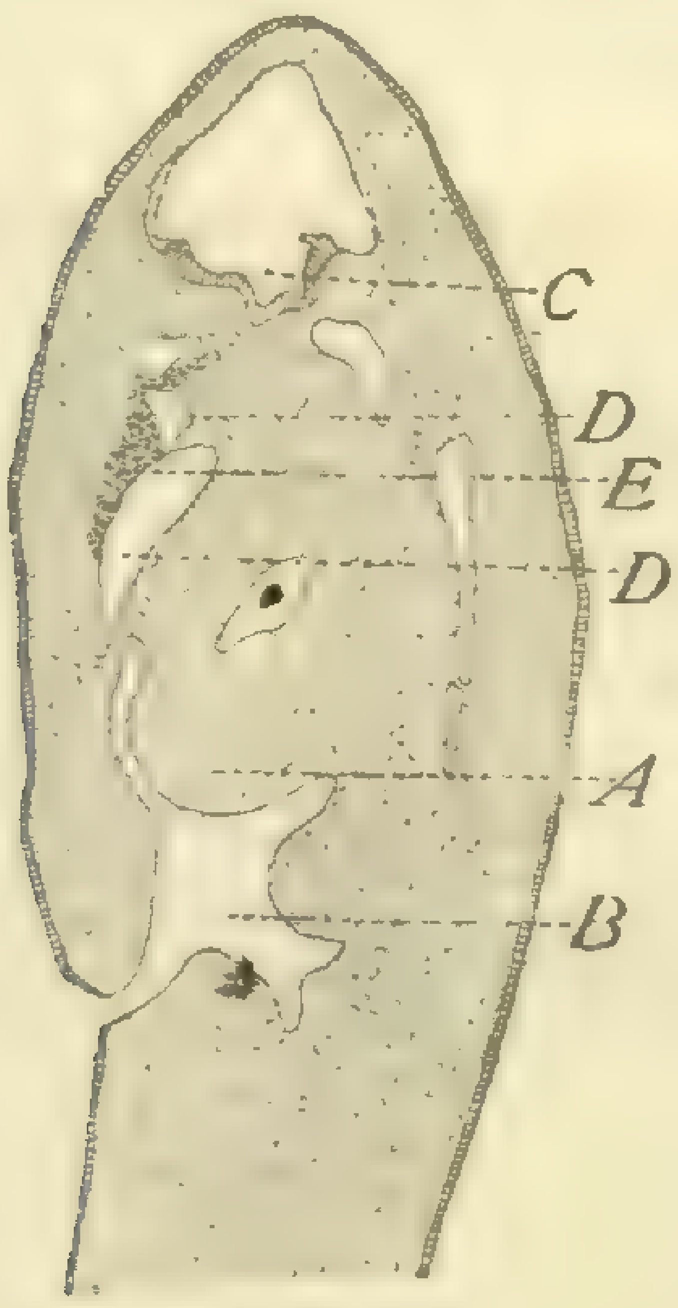

FIG. 6.

FIG. 7.

FIG. 8.

FIGS. 6, 7.— Development of pharynx during presence of reproductive organs. *A*, penis; *B*, genital chamber; *C*, digestive tract (in 6 the wall has broken down between it and the degenerating cavity); *D*, cavities due to degeneration of reproductive organs; *E*, pharynx; *F*, position of pharyngeal pore.

FIG. 8.— Position of regenerating pharynx with respect to genital duct and pore. The new organ appears to one side of the pore but on the same level. The dotted lines indicate direction of duct in following sections.

tions, such as lateral, ventral, and oblique, should be noted in connection with any hypothesis of the relation of the pharynx to the axial gut.

As regards the process of regeneration in the posterior pieces of worms cut behind the genital pore when the reproductive organs were believed to be fully developed, the process of formation seems identical with that which takes place during the absence of these organs. Consequently there is no need to describe what takes place.

I wish to express my indebtedness to Prof. T. H. Morgan, under whose direction this work has been done.

BIOLOGICAL LABORATORY, BRYN MAWR COLLEGE.

A STRUCTURAL FEATURE CONNECTED WITH THE MATING OF DIEMYCTYLUS VIRIDESCENS.

WILLIAM A. HILTON.

THERE seems to be very little doubt at present that the fertilization of Urodela is internal. Since Spallanzi in 1785 proved internal fertilization must take place with Triton, many investigators have shown conclusively that such is the case in other species.

The mating habits of a number of salamanders have been observed, but very much is yet to be learned about many forms concerning which we now know little more than the mere fact that fertilization is internal; however, it seems very probable that in all Urodela fertilization is accomplished by a similar method. In most cases the courtship is more or less complicated and terminates with the female following the male, who emits a spermatophore containing zoösperms, which is received by the cloaca of the female as she passes over it.

There are many variations in the mating habits of different forms described, but unfortunately few species are easy to observe. Of American forms practically nothing is known of the more terrestrial species. *Diemyctylus viridescens* and *D. torosus* of the aquatic species are about the only ones in which a satisfactory idea of the mating has been obtained.

A number of observations have been made upon European salamanders by Robin ('**74**), Gasco ('**80**), and Zeller ('**90**), who have given good accounts of their habits. With Triton, for instance, Zeller has carefully described the antics of the male before the female; these may extend over a period of hours; he rubs against her and rushes before her. At length she is attracted by him, and as he moves off she follows and receives

in her cloaca the spermatophore which he emits. This method of mating is very commonly described among salamanders, but variations occur; for instance, in *Salamandra maculosa*, and in *Salamandra atra*, Siebold ('58), Pfitzner ('80), and others describe the male perched upon the female's back; he clasps her for a period before spermatophores are voided. In these cases the male is usually perched upon the center of the female's back. In *Megapterma montana* and several others Bedriaga ('82) says the male grasps the female and emits spermatophores while still clasping her.

Ritter ('99) in *D. torosus* described, so far as he was able, a method of fertilization similar to that given by Bedriaga in several species; that is, the male emits spermatozoa while clasping the female. The mating of *D. viridescens* has been carefully described by Zeller ('90), Gage ('91), and Jordan ('91), and, so far as the final result is concerned, the process may be said to be similar to that described by Zeller and others for many forms of Salamandridæ, but in several particulars the mating habits are peculiar and deserve further attention.

As breeding season approaches with Diemyctylus, a crest appears upon the already broad tail of the male, and the cloacal regions of both male and female enlarge. It is stated by some that during this time the colors of the male become brighter; but this is probably exaggerated, as there is but little difference in the color of the male and female at this time, except possibly one or the other may have recently passed the red land stage and not yet attained the deeper color of the more mature individuals, or it may have just shed its skin. With Diemyctylus there is much less difference in the sexes than is found in many European Urodela, yet there are several striking differences, most of which have been noted. The female differs from the male at all seasons of the year by having more slender hind legs, and during breeding season there are on the undersides of the male's hind legs black, wartlike, horny elevations, probably developed to aid the male in clasping the female. These have often been described, but as this method of clasping the female is rare with European species, the occurrence of these organs is seldom mentioned with them.

Cope ('89) in his work on Batrachia describes a series of three to four pits along the sides of the head just back of the eye; he regards these as not constant for the species (Fig. 1).

After examining a considerable number of animals I have come to the conclusion that these pits are constant structures. In adult males there are usually three to four quite large, deep pits, which can be seen without difficulty extending from just back of the eye along the side of the head. In adult females, as a general thing, one would say there are no pits, but on a more careful examination one to four small depressions are often seen; these usually appear as pin pricks, or minute depressions in the skin. They are similar in structure to those found in the adult males, but are much smaller and less developed in the female.

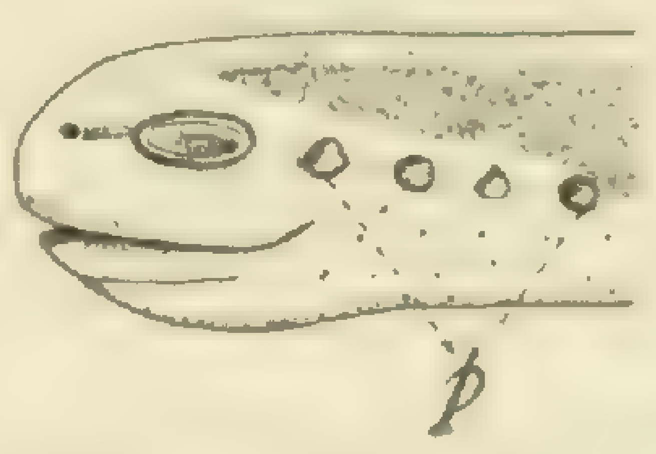

FIG. 1. — Side view of the head of an adult male Diemyctylus. *p*, pits. About natural size.

In early larval forms there are no signs of depressions or pits in either males or females, but in medium-sized to large red males there are along the sides of the head minute depressions which look very much like those found in the adult females, and more or less advanced, according to the size of the animal.

In early red females, as a usual thing, no pits are found, but in later red forms small beginning pits are sometimes present and sometimes absent; but judging from all the individuals examined it may be stated that as a usual thing these small pits of the female make their appearance at about the time the red land form changes to the viridescent water form, and that the corresponding structures in the male make their appearance in the small red forms about the time that their sex can be determined by dissection.

Before speaking of the significance of these structures which are so well developed in the adult male and so rudimentary in the female and young, it will be necessary to speak somewhat further of the mating habits. Usually in captivity during the fall, winter, and spring the male at once settles upon the female's back and clasps her just in front of her fore legs with his powerful back legs in such a manner that it is impossible for her to escape and, at the same time, possible for him to

bring his head down in contact with hers. Although she is unable to escape, in many cases she may struggle, carrying the male with her for a short distance; but usually it is the other way, and the male jerks the female about after having been perched quietly on her back for a short time. This jerking about is not without system, for almost invariably the male jerks the female somewhat and places one side of his head just below the top and a little back of the eye, in contact with that of the female, leaving his head there for a few seconds and waving his tail with a gentle fanning motion. After a short period he jerks the female about in such a way that the other side of his head occupies a similar position in regard to the female's nose, pulling her violently in order to do this. This touching one side of his head and then the other side to the female's snout, accompanied by the more or less necessary jerking about in the water and fanning movements of the tail, continue for some time, and after a considerable number of these jerkings the male slowly leaves the female, his cloaca expanded, and is usually followed closely by the female, whose nose is near his tail. The male moves slowly forward and throws his body into serpentine undulations, and a spermatophore is emitted which may come to the cloaca of the female as she follows him farther along.

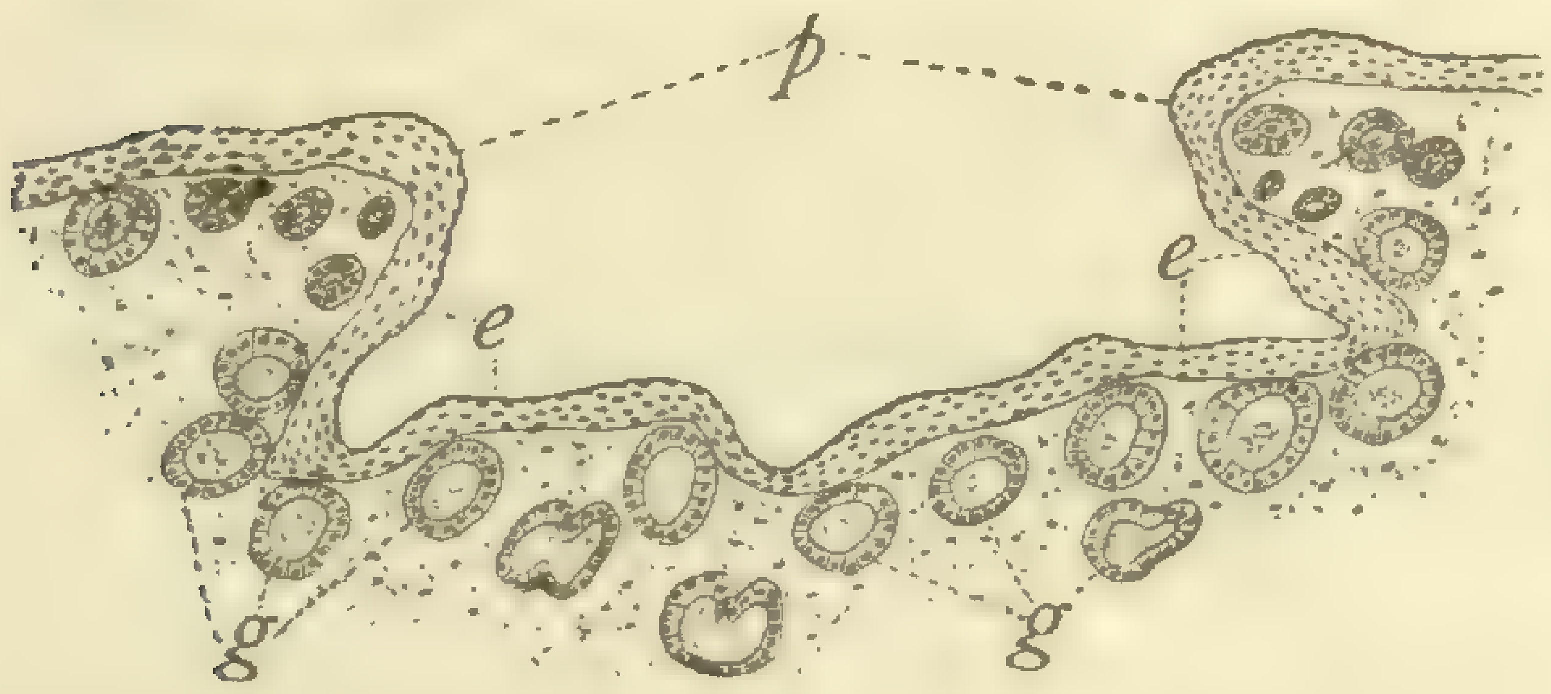

FIG. 2. — Section of a pit and glands of an adult male Diemyctylus. *g*, gland tubules; *e*, epithelium of pit. × 30.

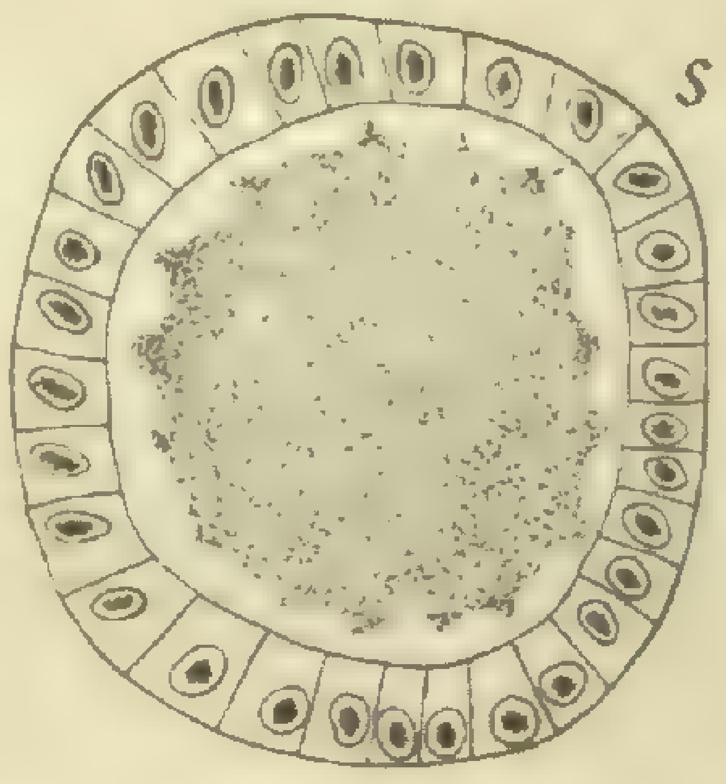

FIG. 3. — Section of a tubule of an adult male Diemyctylus. *s*, secretion. × 210.

The question naturally arises as to what relation these constant habits have towards the accomplishment of fertilization; of course it is evident that it is necessary for the male to be followed by the female in order that she may receive the spermatozoa which he emits in masses or spermatophores, and her following him may be due to an attraction which he exerts over her, but what is the nature of this attraction?

As indicated by Jordan ('**91**), and as simple experiments in feeding captive Diemyctyli show, probably the strongest sense of the newt is either the sense of smell or the tactile sense ; the sense of sight is not particularly well developed. Now, to return to the pits on either side of the head ; upon sectioning these pits it was found that a number of simple gland tubes were collected about the bases of the pits, and these tubules (Figs. 2, 3, 4), although not opening widely in the pits when not active, may be seen to have places where the cell nuclei were drawn out and arranged parallel with the epithelial nuclei ; but when the glands are filled with secretion a few well-marked openings into the pits may be found (Fig. 5). These pits are formed from simple depressions or ingrowths of epithelium, and the epithelium which lines the pits does not differ in any way from that which covers the surface of the body (Fig. 6). The pits were found to begin in about half-grown red males or very late red females. As adult life is reached these pits or depressions become broader, and usually deeper, and together with this broadening and deepening there is an increased development of the glands, which become very numerous in adult males.

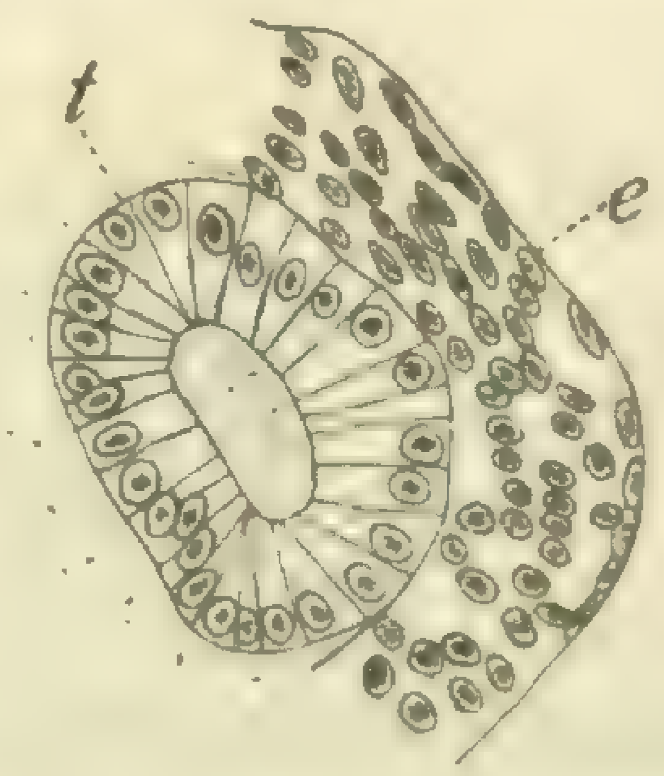

Fig. 4. — Section of a tubule and pit epithelium from an inactive gland of an adult male Diemyctylus. *t*, tubule ; *e*, epithelium. × 210.

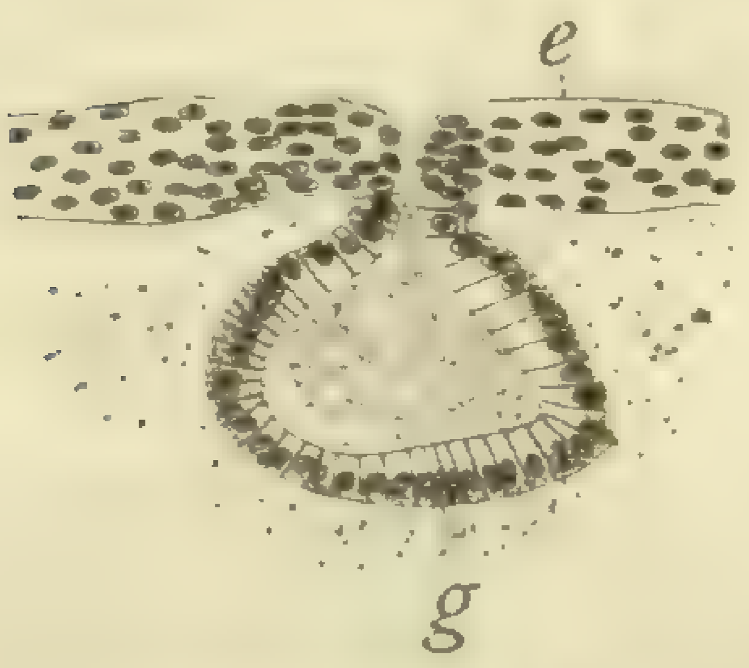

Fig. 5. — Section of a tubule from an adult male Diemyctylus, showing the opening into a pit. *e*, epithelium ; *g*, gland tubule. × 105.

The glands are first formed when the pits are hardly more than narrow insinkings of the skin, and, as Ancel (**1901**) states for other skin glands of Amphibia, they are derived from the ectoderm. The cells which form the rudiments of these glands are derived from those of the insinking, or directly from the adjoining surfaces of the skin (Fig. 7). The little masses of cells which develop into glands become nearly separated from the epithelium

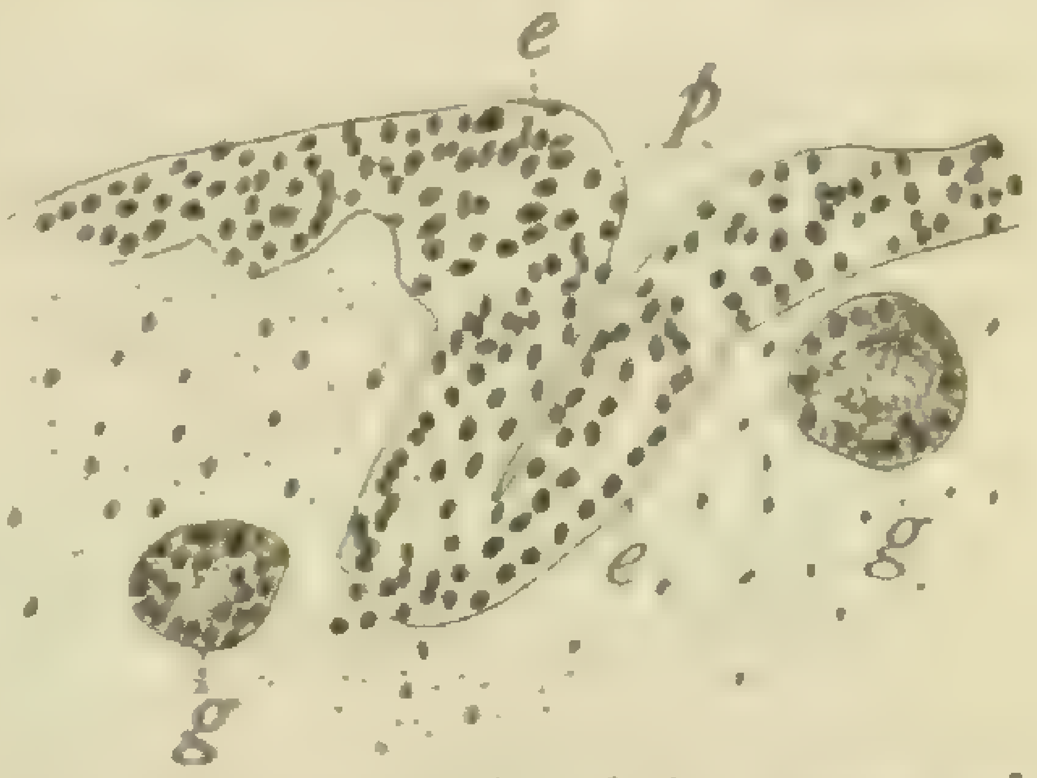

Fig. 6. — Section of a pit in a young red male Diemyctylus. *e*, epithelium ; *g*, rudimentary gland tubules. × 105.

from which they were derived, and the communications with the exterior by means of minute ducts are not formed until much later. The cells of the early rudiments of glands soon begin to be arranged in a more and more columnar manner, and after they are arranged in this way the duct to the exterior is formed partly from cells of the gland itself and partly from the epithelium of the pit. The fully developed gland is simple, saccular, or slightly tubular, with a very small duct. Sometimes glands are found which seem to be partially divided into several portions; that is, have one, two, or more lumens branching off from the main one (Figs. 8, 9). New glands are formed from the old ones in this way, and although these dividing tubules are found most abundantly in half-grown specimens, a few of them are often found in the adult. These glands are more perfectly formed in those individuals where the pits are best developed; but those in a very active condition, with their lumens widely distended, were only found in adult males during the breeding season. During the mating season, either in fall or spring, these glands were very much enlarged in the adult males, their epithelial cells were much like low cubes, and the tubules possessed large lumens (Figs. 3, 10).

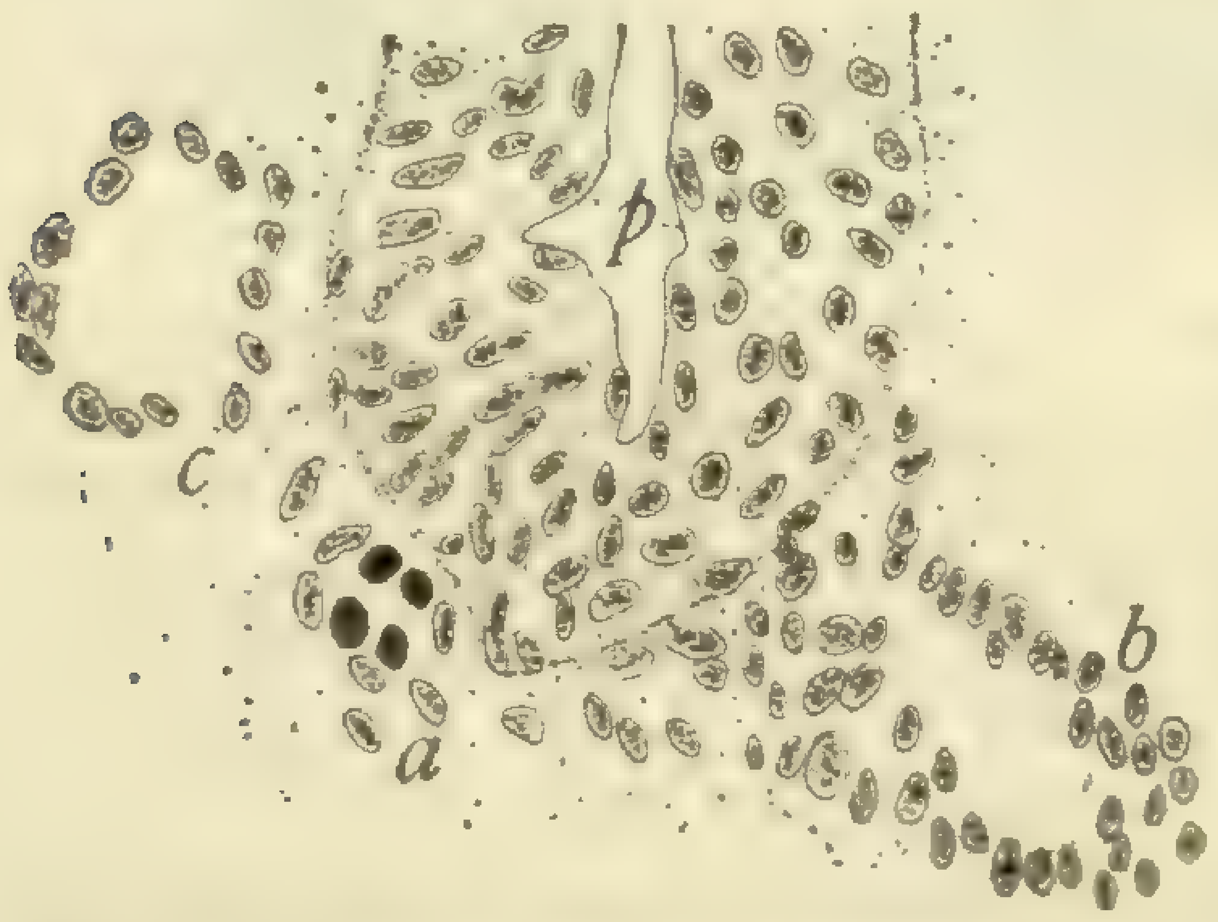

FIG. 7. — Section of a pit of a young red male Diemyctylus. *p*, pit; *a*, early stage of a developing gland; *b*, later stage of developing gland; *c*, still later stage of developing gland. × 210.

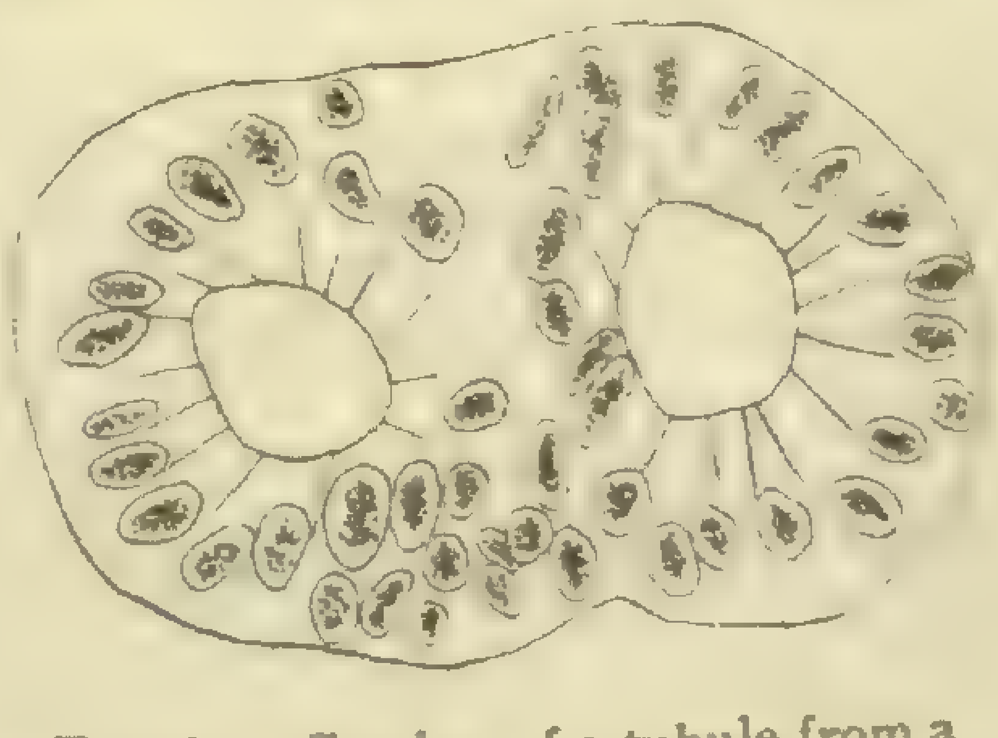

FIG. 8. — Section of a tubule from a red male Diemyctylus of nearly adult size. × 260.

When these glands were sectioned out of breeding season a very marked contrast was noticed; their lumens were much diminished, the cells reached and nearly touched in the center and no colloid secretion was present (Fig. 4). These little pits of the immature animals or of the adult females have at their bases a few masses of cells, or a few small gland tubules, which are undoubtedly the beginnings or remnants of the

glands so characteristic of the adult males (Fig. 11); sometimes one or two tubules appear to have secretion in the lumens, and some have openings into the pits.

To recapitulate: The pits in the adult males are almost invariably well marked, while those in the females, when they occur, are rather difficult to detect; and then, too, the gland tubules in the male are very numerous (Fig. 2).

FIG. 9. — Section of a tubule from a red male Diemyctylus of nearly adult size. *l*, lumen. × 260.

Adult males taken at other times than the breeding season, as a usual thing, show the gland tubules in a resting state; the lumens of the glands commonly have the cells almost touching each other at the center, but males taken when breeding show these gland lumens filled with secretion and the cells appear as a low epithelium.

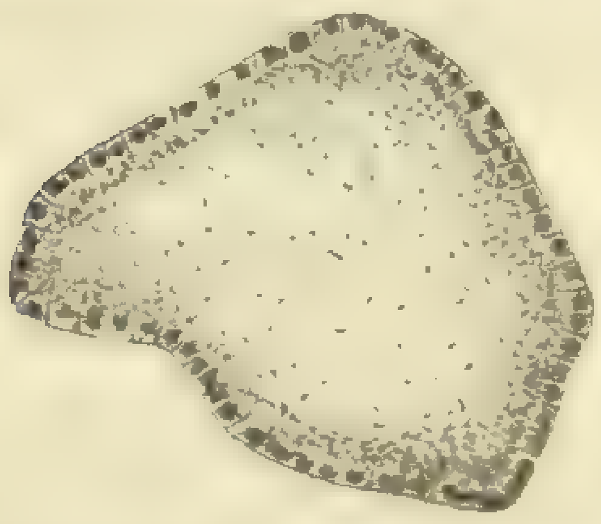

FIG. 10. — Section of a gland tubule from an adult male: taken during mating. The tubule is filled with secretion. × 1.5.

It may be that these glands which are developed so extensively in the male, and placed in a position which favors them, are for the purpose of attracting the female by means of some secretion.

Although, as already spoken of, similar mating habits have in general been described, they are not exactly the same as in *D. viridescens*, nor have similar glands or pits been described for other forms. Ritter, in an interesting paper on *Diemyctylus torosus*, describes no such structures, nor was I able to detect any trace of such pits or glands in several specimens examined; and, in fact, as already stated, the mating habits are entirely dissimilar in the two species.

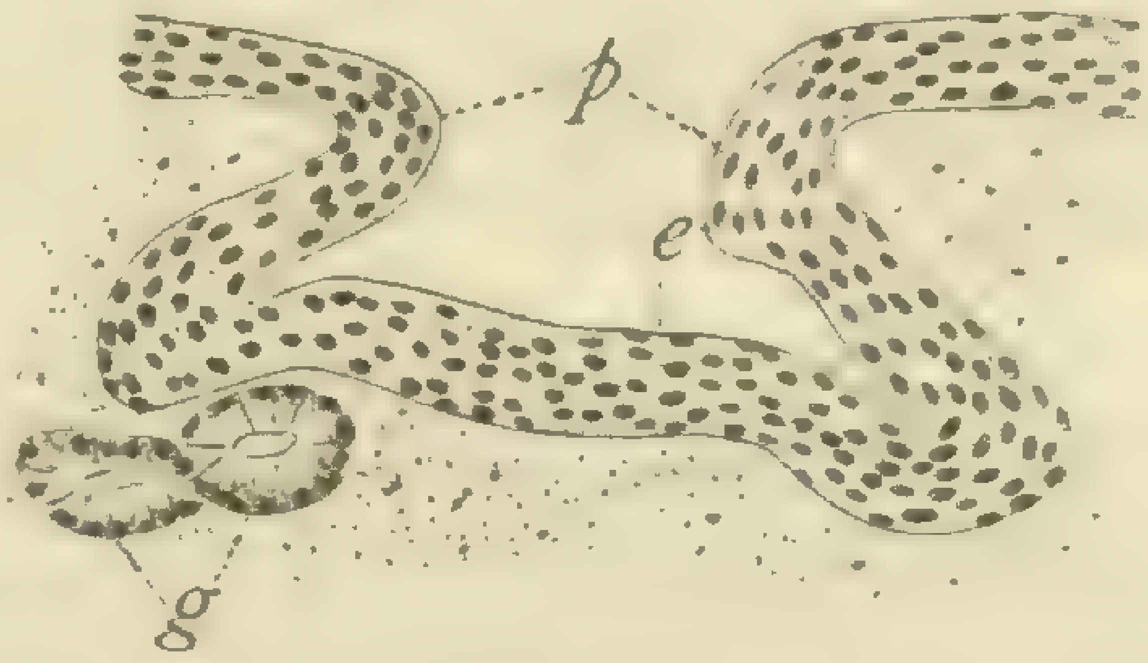

FIG. 11. — Section of a pit from an adult female Diemyctylus. *e*, epithelium of pit: *g*, rudimentary gland. × 105.

GENERAL SUMMARY.

1. The glands on the side of the head of *D. viridescens* reach their complete development only in adult males, and according to my observations are most active during the time of mating.

2. The pits are formed from invaginations of the epidermis, and the gland rudiments are derived from these invaginations or from the adjoining epidermal surfaces.

3. Adult males always possess three to four large, well-marked pits. Adult females sometimes have one to four pits on a side, and also a few small gland tubules, some of which may open into the pits.

4. Early red larval males have small pits about as soon as the sex can be determined by gross dissection, and at the bases of the pits there are usually a few small gland tubules.

5. Pits when present in red females make their appearance *late*, usually just before the red terrestrial changes to the viridescent aquatic form; at this time the pits are seen to be shallow depressions of the skin, and no gland tubules are present.

6. No pits or glands were found in the early larval form of *D. viridescens.*

7. The glands described occur only when pits are present, and the tubules have openings into the pits in the adult males, and sometimes in the females.

8. In mating, the female follows the male only after the usual courtship, in which first one side and then the other side of the male's head touches the female's snout.

In the preparation of this paper I have become greatly indebted to the Department of Histology of Cornell University and the professors in charge, and also to Mrs. Gage for lending me her slides of Diemyctylus heads to complete my series of stages.

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SOME HITHERTO UNPUBLISHED OBSERVATIONS OF ORESTES ST. JOHN ON PALEOZOIC FISHES.

C. R. EASTMAN.

Mr. Orestes St. John, the only pupil of Professor Louis Agassiz who took up the study of fossil fishes, and whose researches in this class of vertebrates, published in Vols. VI and VII of the *Illinois Palæontology*, are among the leading contributions to the literature of American Paleozoic forms, passed his early life in the vicinity of Waterloo, Iowa, and during a period of fifteen years, dating from 1863, brought together one of the finest collections of Meso-Devonian fish remains ever obtained from that state. This collection has recently been deposited in the Museum of Comparative Zoölogy at Cambridge, where Mr. St. John was formerly assistant in paleontology, and it is understood that further collections from the Carboniferous of the Mississippi valley are to follow. In the same institution are also preserved some of the type specimens which are described in Vol. VII of the *Illinois Reports*, with casts of others that are now in the State Museum at Springfield, Illinois.

Accompanying the St. John collection of Devonian fishes is a manuscript description and drawing of a nearly perfect mandibular (gnathal) plate of *Dinichthys pustulosus*, an interesting species whose occurrence in Iowa, Illinois, and Wisconsin has only recently been made known. As this species was originally described from portions of the dermal armor, examples of the dentition being at that time unknown, and as doubt has been expressed [1] whether it really pertains to Dinichthys rather than to some other coccostean, it is of interest to find its dinichthyid nature confirmed by this early discovery of St. John's, the credit

[1] Dean, D. Palæontological Notes, *Mem. N. Y. Acad. Sci.*, vol. ii (1901), p. 122.

for which is after a long period of oblivion finally secured to him. The actual specimen, whose description follows, appears to have dropped out of sight altogether; but if still in existence, the present account may perhaps lead to its resurrection.

Other interesting observations of St. John with reference to Edestus and Cochliodus are contained in the form of a personal letter to Professor Agassiz, written in 1871, extracts from which are quoted in the following, and his sketch of *Edestus minor* is here reproduced. Detached segments of *E. heinrichi* have been figured by Newberry[1] and Trautschold,[2] and a corresponding example of *E. minor* from the vicinity of Moscow is described by Karpinsky,[3] but St. John's specimens are the only ones, so far as the writer is aware, that have been found of the latter species in this country.

Professor Agassiz was one of the first to pronounce upon the nature of these problematical fossils, and compared them with the rostral prolongation of Pristis. Leidy saw in their segmented condition a resemblance to the compound maxillary of Lepidosteus, but later regarded them as elasmobranch spines, an opinion concurred in by Sir Richard Owen, Newberry, Woodward, and most modern writers. They are now definitely determined, however, to be the symphysial dentition of cestraciont sharks.[4]

I. ON THE OCCURRENCE OF DINICHTHYS IN THE HAMILTON LIMESTONE OF ILLINOIS.

(August, 1882.)

"Professor A. H. Worthen has obtained from the Devonian limestone of Andalusia, Rock Island County, Illinois, a nearly perfect example of the right mandibular dental plate of a small species of Dinichthys, which is quite distinct from either of the two forms already described by Dr. Newberry from the Ohio

[1] *Ann. N. Y. Acad. Sci.*, vol. iv (1888), Pl. V, Figs. 2 *a*, 2 *b*; *Monogr. U. S. Geol. Surv.*, vol. xvi (1889), Pl. XXXIX, Figs. 2 *a*, 2 *b*.

[2] *Bull. Soc. Imp. Nat. Moscou*, vol. lviii (1883), Pl. V, Figs. 1, 2.

[3] *Verh. k. russ. Mineral. Ges. St. Pétersbourg* [2], vol. xxxvi (1899), pp. 381, 450, Text-figs. 15, 62.

[4] *Geol. Mag.* [4], vol. ix, p. 148; *Bull. Mus. Comp. Zoöl.*, vol. xxxix (1902). No. 3.

Shale [*D. herzeri* and *D. terrelli*]. The age of the beds from which this specimen was derived is unquestionably not later than the Hamilton, as is shown by associated Brachiopoda, etc., characteristic of the Hamilton of Iowa and Illinois. The present specimen, therefore, affords the earliest indication of this genus yet discovered.

"The characters displayed by the Illinois specimen, which serve to distinguish it from the Ohio forms, may be summarized briefly as follows:

"1. The dental plate under discussion, while resembling *D. herzeri* in general form and proportions, differs from the latter in the character of the cutting edge, which is destitute of the series of conical denticles occurring in that species. The dentary portion of the mandible is similarly well demarcated from the spatulate posterior shaft, and is similarly rounded along the front margin. The anterior beak is much produced, irregularly lozenge-shaped in transverse section, with a sharply rounded anterior angle and a sharp posterior cutting edge. A deep notch separates the cusplike beak from a low, round-crested prominence in advance of the cutting edge of the dentary, which is deeply beveled along its outer face by attrition against the upper dental plates. To the same cause is probably to be ascribed the gently concave curve of the trenchant border itself. The latter terminates abruptly behind, and along the posterior slope of the dentary are to be counted the bases of five small downwardly directed denticles. The lower portion of the posterior slope is smooth and meets the shaft in an obtuse angle. In this denticulation of the posterior slope of the dentary, and perhaps also in the presence of an elevated prominence or denticle behind the anterior beak, are to be found the principal differences between the present specimen and *D. terrelli*.

"2. The form of the shaft is not unlike that of *D. herzeri*, except that it is more contracted immediately behind the dentary portion, and more regularly arched along its lower border before passing into the acutely rounded posterior extremity. The general outline of the shaft is spatulate, its outer face moderately convex, and it is separated from the dentary portion

by a shallow, curved depression. *D. terrelli* has a relatively shorter and more massive posterior shaft. As contrasted with the compact structure of the dentary portion, which has almost the density of enamel, the spatulate shaft is finely striato-punctate, and presents more the condition of osseous tissue.

"3. In *D. herzeri*, the secondary prominence or denticle behind the anterior beak is buttressed on the inner side by a prominent angulation or ridge [this is really part of the denticle, and occurs in other species as well], which sweeps from the apex of the denticle downward and backward until it merges with the thickened portion of the dentary bone. But in the

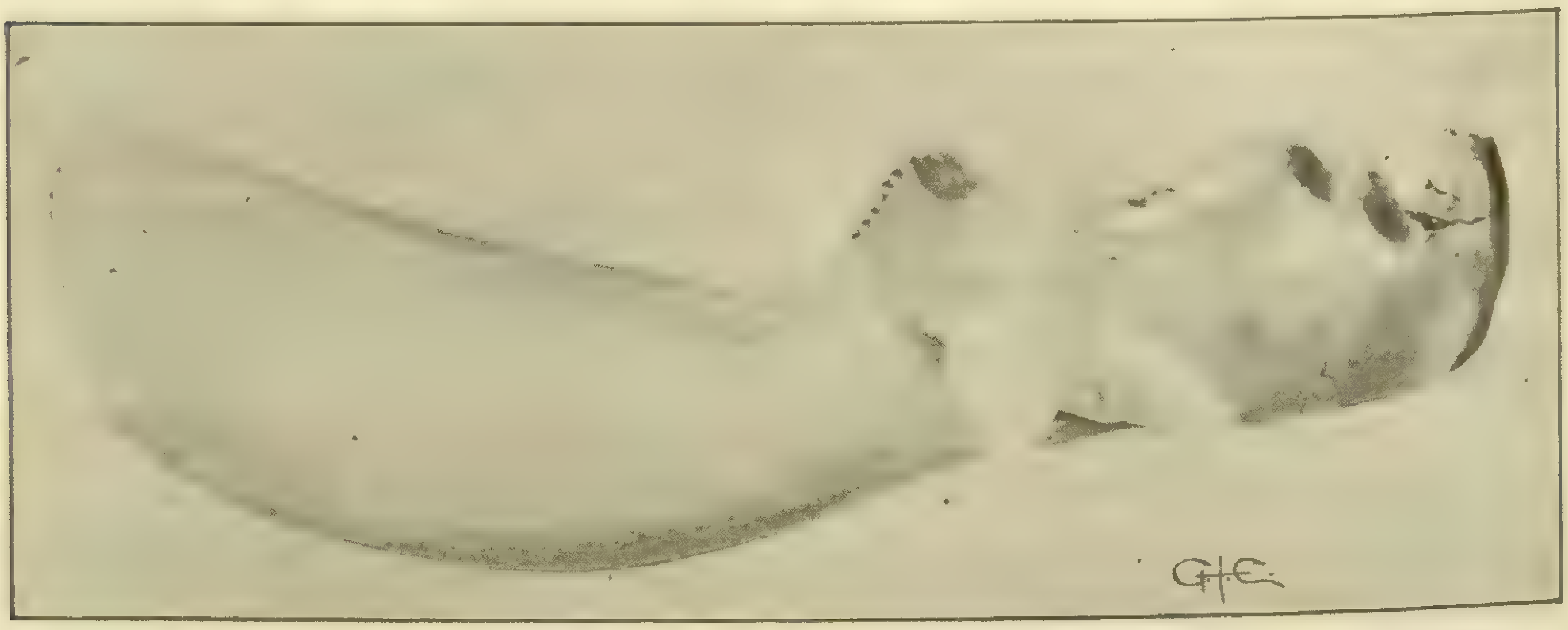

FIG. 1. — *Dinichthys pustulosus* Eastm. Hamilton limestone; Andalusia, Ill. Right gnathal plate. × ½ (nearly).

present species the entire inner surface is deeply excavated, and there is no evidence of a buttress having occurred.

"4. The present specimen evidently belonged to a species of much smaller size than either *D. herzeri* or *D. terrelli*, since the total length of the mandible is only 20 cm., while both of the Ohio forms exceed 60 cm. That it does not pertain to an immature individual seems plainly indicated by the marks of wear, and general appearance of the bone.

"The salient features which have been pointed out in the foregoing are sufficiently characteristic to warrant the establishment of a new species, which we have pleasure in naming in honor of Dr. J. S. Newberry, to whom we owe the admirable notice of the two first discovered species. In the accompanying figures are shown (*A*), view of right mandibular ramus from

external aspect; (*B*), inner aspect of anterior portion of the dentary; and (*C*), inferior view showing external outline and channel separating the dentary portion from the shaft.

"*Horizon and Locality:* — Hamilton Limestone; Andalusia, Rock Island County, Illinois."

[NOTE. — The specific title which St. John had intended to propose has already been applied by Dr. J. M. Clarke[1] to a gnathal plate from the Hamilton of western New York. Moreover, although St. John clearly has the priority of discovery, the species which he here recognizes as distinct has been described under the name of *D. pustulosus*.[2] Only one of the

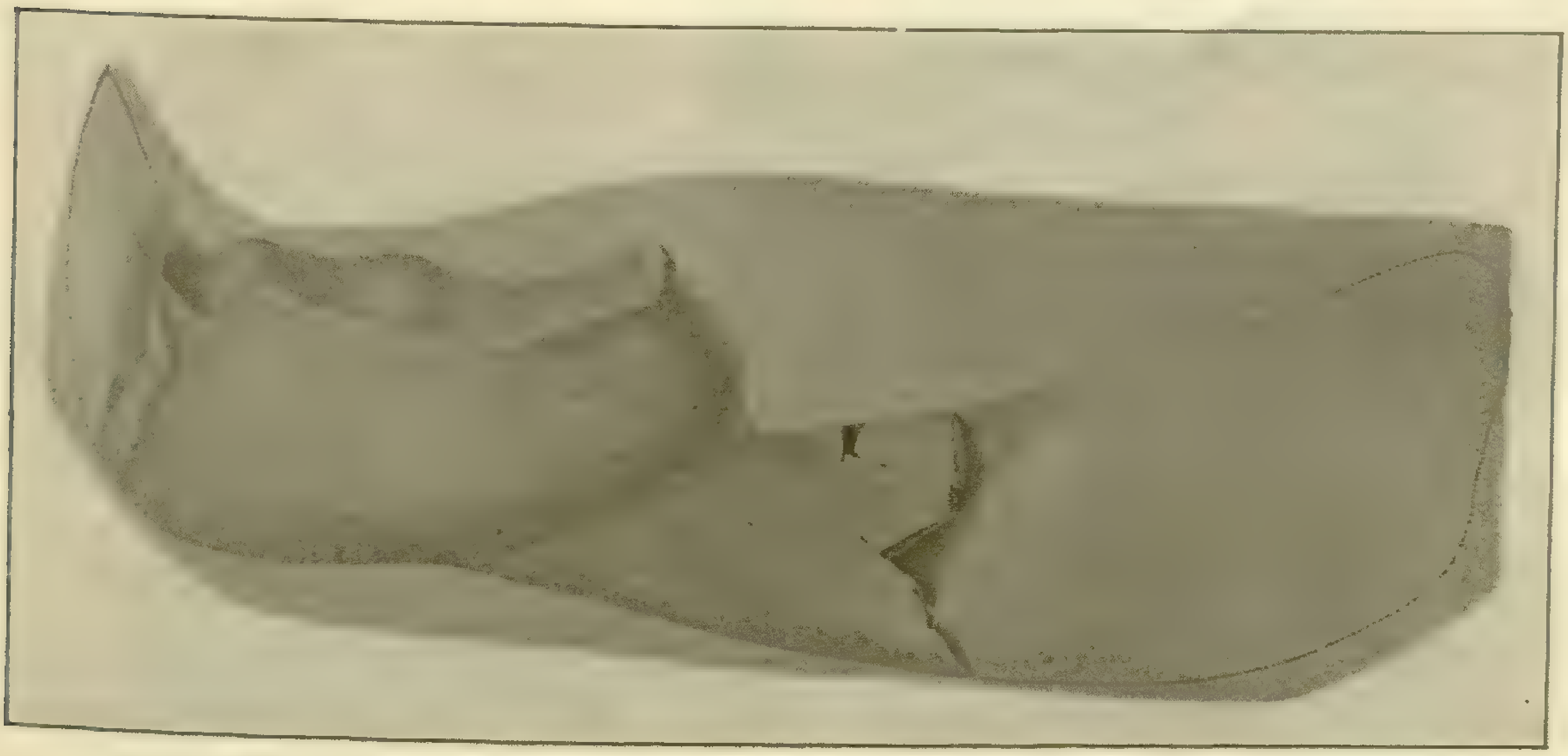

FIG. 2. — *Dinichthys pustulosus* Eastm. Hamilton limestone; Milwaukee, Wis. Left gnathal plate. × ⅔.

illustrations to which he refers is now extant. It is reproduced in the accompanying Fig. 1, and in Fig. 2 is shown a corresponding dental plate belonging to an individual of about equal size from the Hamilton of Milwaukee, the original being preserved in the Milwaukee Public Museum. A fragmentary gnathal of *D. pustulosus*, from the Hamilton of New Buffalo, Iowa, is also preserved in the Museum of Comparative Zoölogy at Cambridge.]

[1] *Bull. U. S. Geol. Surv.*, No. 16 (1885), p. 17, Pl. I, Fig. 1.

[2] *Bull. Mus. Comp. Zoöl.*, vol. xxxi (1897), p. 38, Pl. III, Fig. 4; *Amer. Nat.*, vol. xxxii (1898), p. 748, Figs. 1, 2; *Journ. Geol.*, vol. viii (1900), p. 32, Fig. 1.

II. Observations on Edestus and Cochliodus.

(From a letter addressed to Professor Louis Agassiz, dated Springfield, Illinois, June 29, 1871.)

"My dear Professor :

"Excuse this postscript, but I met with rare success yesterday morning, in the finding of what appears to be the terminal denticle of an immature *Edestus vorax* [*sic*] Leidy. This is

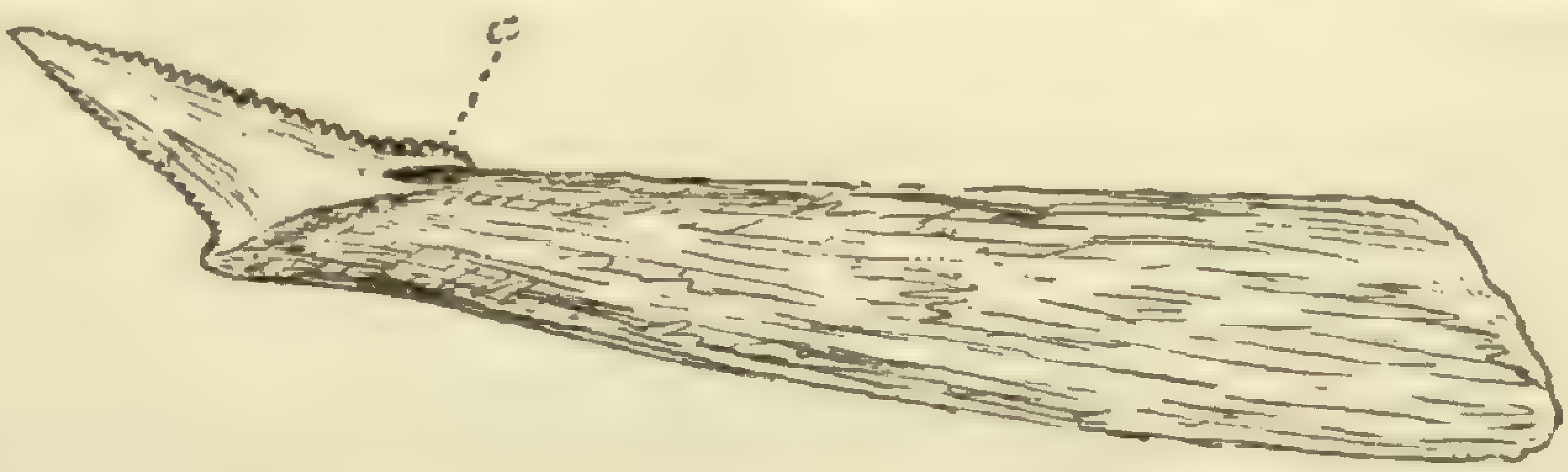

Fig. 3. — Detached segment of *Edestus minor* N. and W. Coal measures ; Illinois.

the second specimen known to me in which only a single denticle occurs — the other one, from a similar horizon in the Coal Measures, being referable to *Edestus heinrichi* N. and W., and readily distinguished from the former species by the stronger [development] and more erect position of the denticles. The slight depression at '*a*' [Fig. 3] indicates the area occupied by the overlapping of the posterior extremity of the succeeding [*i.e.*, preceding] denticle, which, however, is not developed in the present individual.

Fig. 4. — *Cochliodus sancti-ludovici* (St. J. and W.). St. Louis limestone ; Alton, Ill. Enlarged.

"I also received last evening a remarkably beautiful specimen of Cochliodus sp. from the St. Louis limestone. The specimen is very small, and presents two, or a pair, of the large posterior teeth in their relative position ; but what is particularly interesting, it shows the coarsely osseous [*i.e.*, cartilaginous] posterior prolongation of the rami, which appear to be terminated in articular processes much in the same manner as occurs in the modern Cestracion. The two nodes *a*, *a* [Fig. 4] are apparently the anterior prolongation of the rami for the support of the

dental plates in that portion of the mouth. And of these anterior teeth I believe we have specimens — a very small, narrow, enrolled form — much resembling the 'second' tooth of *C. contortus*.

"The genus Trigonodus of Newberry will have to be abandoned, it being identical with his Sandalodus. The described forms of the latter probably represent the superior dentition.

"Very respectfully,

"O. St. J."

[NOTE. — It is evident from St. John's pen-and-ink sketch, reproduced in Fig. 3, that his specimens of Edestus belong to *E. minor* N. and W., instead of to *E. vorax* Leidy. The confusion probably arose from the fact that Leidy's name is inadvertently applied to the type of *E. minor* by Newberry and Worthen in their explanation of Plate I of the fourth volume of the *Illinois Palæontology*, an error which was subsequently corrected. The type specimen of *E. vorax* is now preserved in the Museum of the Academy of Natural Sciences of Philadelphia; that of *E. minor* in the Cabinet of Amherst College; and that of *E. giganteus*, which is scarcely distinct from *E. vorax*, in the Columbia College Museum. The location of the type specimen of *E. heinrichi* has been ascertained to be in the State University at Urbana, Illinois.

The depressions on either side of the median projection at *a*, in Fig. 3, are not marks of contact with an adjoining denticle, as supposed by St. John, but are plainly channelings corresponding to the buttressed condition of the crown in *Campodus variabilis* (N. and W.). In fact, a comparison of the symphysial series of the latter with the type of *Edestus minor* proves that the coronal apices of the two forms are surprisingly alike. The detached segments of Edestus are often pyritiferous, and their decomposition is best arrested by treating them with a film of collodion.

The specimen of Cochliodus referred to in the second paragraph above is figured by St. John and Worthen in Vol. VII of the *Illinois Palæontology*, Pl. viii, Fig. 8 *a*, under the name of *Pæcilodus sancti-ludovici*. There seems to be no sufficient reason, however, for its removal from Cochliodus. The complete dentition of this genus is known in at least one species, *C. latus* Leidy. A magnificent specimen is described by Newberry and Worthen in Vol. II of the same work, in which the two pairs of enrolled dental plates belonging to either side of both upper and lower jaws were found in natural association with the anterior series, the latter having the form of "Helodus" teeth. The symphysial series of the same species has been described by Newberry (*Ann. N. Y. Acad. Nat. Sci.*, Vol. xvi, p. 301, Pl. xxiv, Fig. 24) under the name of *Helodus coxanus*. In *C. contortus* the anterior and symphysial series have not yet been definitely recognized as such.]

CAMBRIDGE, MASS.

THE MARSH OR RICE-FIELD MICE OF THE EASTERN UNITED STATES.

S. N. RHOADS.

THE status of the rice-field mice (Oryzomys) found in the marshes of the Atlantic coast from Delaware Bay to the Gulf of Mexico has been of uncertain fixity since our first knowledge of their existence in 1837.

In that year a certain Rev. Dr. Harlan of the Academy of Natural Sciences of Philadelphia is stated by the Rev. John Bachman to have used the skull of one of these mice, sent by him for identification to the Academy, as the basis of the first description of the species, published in *Silliman's Journal.* The name there given was *Mus palustris*, and the professed type a specimen in the Academy's collection labeled as coming from "Fast Land," near Salem, N. J. Until recently no other specimens had been secured in New Jersey, and naturalists had so far concluded that the animal was never found there that Mr. Outram Bangs, in a recent paper on the mammals of Florida and Georgia (*Proc. Bost. Soc. Nat. Hist.*, p. 188, 1898), decided to ignore Harlan's statement as to the type locality and refer it to South Carolina, whence the Bachman specimens were procured. But recent investigations, based on the chance rediscovery of this interesting mouse in the coast marshes of Cumberland County, N. J., as announced two years ago by Mr. Witmer Stone, have enabled the writer to secure a sufficient series of specimens of Harlan's typical *O. palustris* to settle some points in this controversy, as indicated in the following brief synopsis.

1. Harlan's marsh mouse, *Oryzomys palustris* (Harlan).

1836 *Mus palustris* Harlan. *Silliman's Amer. Journ. Sci.* Vol. xxxi, p. 386.

Type locality: "Fast Land" (a term having no meaning to present inhabitants except as applied to upland, or land not needing reclamation from tides), near Salem, N. J.

Geographic distribution (of *palustris*, typicus): Southern New Jersey to northeastern South Carolina.

Habitat: Tide marshes of the coast, inland to the limits of brackish water. Wintering in muskrat houses in New Jersey.

Description of species: Size, smallest of the Atlantic coast group. Skull, relatively large and massive. Colors, above grayish black with pale tawny or ashy suffusion. Underparts wholly grayish white. Fur dense and soft. Average measurements of ten old adults from New Jersey and North Carolina: total length, 237 mm.; tail vertebræ, 108 mm.; hind foot, 29 mm.; ear from crown, 12 mm. Skulls of two old males, total length (basilar, of Hensel), 37 mm.; zygomatic width, 18 mm.

2. Bachman's marsh or rice mouse, *Oryzomys palustris oryzivorus* (Bachman).

1853 *Arvicola oryzivora* Bachman. *Quad. N. Amer.* Vol. iii. p. 214.

1893 *Oryzomys palustris natator* Chapman. *Bull. Amer. Mus. Nat. Hist.* Vol. v, pp. 43–48.

1894 *Oryzomys palustris texensis* Allen. *Bull. Amer. Mus. Nat. Hist.* Vol. vi, pp. 177–179.

Type locality: Southeastern South Carolina, between Charleston and Savannah, Ga.

Geographic distribution: Northeastern South Carolina to Orange and Citrus Counties, Florida, Gulf coast to southern Texas.

Habitat: Same as *palustris*, but penetrating farther inland to fresh water.

Description of species: Compared with *palustris* of New Jersey and northern North Carolina (Bertie County) the differences of Georgia and north Florida specimens, alike typical of *oryzivorus* and *natator*, are too slight to allow of the recognition of both the latter-named races. In fact, no palpable departure from *palustris* is manifest until north Florida specimens are examined. As the *natator* form is thus synonymous from an anatomic and zoögeographic standpoint with Bachman's type, I am forced to so consider it in this review.

Oryzivorus, as thus restricted, may be distinguished from *palustris* by somewhat larger size, a relatively much lengthened tail, and a narrower skull. It is a more slender, elongate animal. The colors of upper parts are browner (less gray) than *palustris*, the subapical third of the hairs of back and sides being pale ochraceous brown instead of pale tawny. The buffy shade invades the underparts and gives a slightly soiled wash thereto even on breast and belly, as contrasted with the uniform clear ashy white of *palustris*. Average measurements of three adults from St. Mary's, Ga.: total length, 255 mm.; tail vertebræ, 118 mm.; hind foot, 30 mm.; ear from crown, 15 mm. Of five males from Gainesville, Fla. (from type locality of *natator*, *fide* Chapman): total length, 286 mm.; tail vertebræ, 136 mm.; hind foot, 33 mm.

It will be seen by above figures that the difference in length consists chiefly in the great *relative* lengthening of the *tail*, the body being not

much larger than in *palustris*. In the specimens from Georgia sent me by Mr. Bangs the largest male skull measures only 26 mm. in basilar length by 17 mm. in zygomatic breadth, though the specimen from which this skull was taken is 20 mm. longer than average *palustris*. This illustrates the tendency of the southern animal to elongate in body without corresponding increase in size and caliber.

3. Bangs' marsh mouse, *Oryzomys palustris coloratus* Bangs.

1898 *Oryzomys palustris coloratus* Bangs. *Proc. Bost. Soc. Nat. Hist.* Vol. xxviii, p. 189.

1901 *Oryzomys natator floridanus* Merriam. *Proc. Wash. Acad. Sci.* Vol. iii, p. 277. (Monroe County, Fla.)

Type locality: Cape Sable, Florida.

Geographic distribution: Tropical life zone of southern Florida, south of Caloosahatchee River and Lake Worth.

Habitat: Not given; probably similar to that of its allies.

Description of species: From Bangs: "Upper parts rich, reddish brown, about between hazel and ferruginous. . . . Under parts white, often suffused with cinnamon. . . . Skull similar to that of *O. palustris natator*, but slightly larger."

Mr. Bangs gives much stress to cranial differences between *coloratus* and "*natator*" = *oryzivorus* and *palustris*, some of which are rather exaggerated, and that of the greater size of the supraorbital bead in *oryzivorus* is not held out by my New Jersey series. He admits the greater slenderness of the skull in southern examples. Consonant with this I find the supraorbital bead to be no more pronounced in these, if anything less heavy than in Georgia examples. Measurements (*fide* Bangs): total length of three adult males, 301 mm.; tail vertebræ, 142 mm.; hind foot, 34.93 mm.

No cranial measurements are given by Mr. Bangs. I include Dr. Merriam's *O. natator floridanus* as a synonym. He seems to have omitted *coloratus* entirely in his recent synopsis. The small size of *floridanus* given by Merriam is puzzling.

In conclusion I may acknowledge my indebtedness to Mr. Outram Bangs for loan of specimens of Oryzomys from South Carolina and Georgia.

Audubon, Camden County, N. J.,
April 14, 1902.

NOTES AND LITERATURE

GENERAL BIOLOGY

Iron and Living Matter.[1] — The title together with the first paragraph of the preface gives a fairly correct idea of the contents of this book. A somewhat free translation of the paragraph referred to is as follows : In the course of my bacteriological and morphological studies I, like so many other observers, felt myself simply overpowered with the infinite variety of the vital phenomena and felt an almost irresistible necessity to gather all these phenomena together under some one fundamental principle. In the course of my attempts to find such a principle I came finally to the conclusion that all vital phenomena are due in the last instance to the oxidation of the iron of living matter.

One scarcely feels like taking the author's discussions of the vital phenomena and their causes seriously because they seem so much more like the dreamy wanderings of an imaginative but untrained mind than like a scientific presentation of a coherent set of facts. It is not clear just why or how the author came to decide upon the oxidation of iron as being the one fundamental process back of the life phenomena. He states in the preface that what helped more than anything else to fix this view in his mind was the fact that he had succeeded in explaining by means of it all the enzyme reactions. Indeed the only *experimental* work recorded in the book is that which is intended to prove that the characteristic enzyme reactions are nothing more or less than the effects of oxidations and reductions of the iron which they are supposed to contain.

The experimental work which is supposed to prove this surprising result consists simply of qualitative tests for iron and phosphoric acid in Merck's commercial enzyme preparations ! The author does not seem to understand that the occurrence of traces of iron and phosphorus in commercial enzyme preparations may be only impurities and not a part of the active enzyme, nor does he seem to know

[1] Sacharoff, U. *Das Eisen als das thätige Prinzip der Enzyme und der lebendigen Substanz.* Translated into German by Dr. M. Rechtsamer in Odessa. Jena, Fischer, 1902. 8vo, 83 pp., 2 pls.

that enzymes have been the subject of considerable careful investigation during the past fifteen years and that their nucleoproteid nature which he has just "discovered" is now in fact being given up by the men who are most prominent in the chemistry of the enzymes. Only a few months ago Pekelharing prepared a pepsin which contained no phosphorus ; this pepsin still contained a minute trace of iron, as shown by qualitative tests, but it was too small to be determined quantitatively and Pekelharing paid no further attention to it. There is no reason for supposing that Pekelharing could not purify this pepsin still further and thus get rid of the last traces of iron, as he has already removed the last traces of phosphorus, should there be any sufficient object in his doing so.

Since the only experimental evidence cited by the author is thus meaningless there is scarcely any point in following him in a review of this kind through other subjects, such as synthesis of living matter, growth, cell division, reproduction, muscle contraction, the activity of the sense organs, and the chemical processes of the central nervous system. The discussions seem all like the products of a wandering mind whose scientific bearings have been completely lost.

It seems surprising that a firm like that of Gustav Fischer at Jena could have been induced to publish a work of this kind.

O. F.

A New Laboratory Manual of Biology. — The teacher of biology is confronted not only with the problems of his own science, but with those of how best to teach it, and a laboratory manual is a provisional answer to many questions of the second kind. From this standpoint Hargitt's[1] *Outlines* will be of much service to teachers. It abandons the older method of beginning with the simplest representatives of animals and plants which are at the same time least familiar and most difficult of study, and adopts the more recent practice of introducing the subject by well-known types, in this instance the frog and the fern. Then follow exercises on the animal and the vegetable cell, and finally a series of type animals and plants ranging from hydra and the molds to the grasshopper and flowering plants. The mingling of plants and animals in the latter part of the work, though a time-honored practice, destroys the unity which the plant and the animal kingdom ought to show and substitutes nothing of special value for it. The text, which is for the most part clear, is

[1] Hargitt, C. W. *Outlines of General Biology*. C. W. Bardeen, Syracuse, N.Y. 164 pp.

unaccompanied by figures, thus throwing the student more completely on his own resources. Here and there it is perhaps too descriptive, as, for instance, on page 74, where the form of the jellyfish might have been left for the student to make out for himself. Occasionally terms could be improved. Thus, on page 19, in the account of the external apertures of the frog, *anus* is used for *cloacal opening;* and on page 98 the plates of the starfish are described as *bony* instead of *calcareous.* Except for the wrong font of *s*'s on page 38, the proof reader's work seems to have been done with much care. These defects, however, are insignificant compared with the good qualities of the book, which will undoubtedly find its way to many laboratories where plants and animals are dealt with in a single course.

ZOÖLOGY.

Gegenbaur's Comparative Anatomy of Vertebrates.[1] — The second and concluding volume of this masterly work deals with the digestive and respiratory organs, the organs of circulation, and the urogenital system. The present volume is only a little over two-thirds the size of the first one, and its real subject-matter is still further restricted, in that about one-fifth of its 700 pages is given up to an index of some 20,000 entries, covering both volumes. There are 354 text illustrations. One impression made by the perusal of this volume, as compared with the first, is some lack of completeness. Thus, in the section on the pancreas, though the ducts of Wirsung and of Santorini are described, no exact statement is made as to their relations to the anlages of the gland, and the interesting and important phases presented by them in different mammals is passed over without comment. The lungless condition of many salamanders is only briefly noticed (p. 302). The description of the arterial system is very fragmentary. Almost no mention is made of the coronary arteries, whose conditions in the fishes and in the higher vertebrates present many important modifications. The exact comparison of the aortic arches of the amniota with those of fishes is nowhere very clearly brought forward. Although the relations of the azygos and hemiazygos veins of mammals to

[1] Gegenbaur, C. *Vergleichende Anatomie der Wirbelthiere.* Bd. ii. Leipzig, W. Engelmann, 1901. viii + 696 pp.

the post-cardinal veins of the lower vertebrates is sketched, the instructive variations which these veins show is not even alluded to. Thus, in many places the second volume shows deficiencies where, from the completeness of the first, one would expect to find an ample and well-balanced account. As in the first volume, so in the second there is a strong disinclination to accept the results of embryology. Though this is in some respects an advantage, for in the last twenty years embryological evidence has certainly been given much more weight than it should have had, still its almost complete exclusion is by no means a wise course. The account of the origin of the complex teeth of mammals and the question of the number of generations of teeth in this group, lose much by the omission of embryological facts. So, too, the discussion of the relations of the pronephros to the mesonephros is left in a very unsatisfactory form because of the absence of embryological data. While embryology may have been too exclusively followed by many, its results are too important to be lightly cast aside. Notwithstanding the defects that have just been pointed out, the volume before us and its companion certainly represent the high-water mark among modern comparative anatomies of the vertebrates, and the author is to be congratulated on his good fortune in having completed a book that will bear comparison not only with the best of contemporary work but with the best that has gone before. P.

Animal Life in the Deep-Sea. — Professor Seeliger's[1] pamphlet of fifty pages presents a very readable popular account of the animal life of the deep sea. After a brief historical résumé of the growth of deep-sea investigations, the effect of the environment on the animals is considered. The icy temperature of the deeper waters is contrasted with the variable temperature of the surface. The influence of the enormous water pressure is well illustrated by comparison with that of atmospheric pressure. The presence of free oxygen and of carbon dioxide and the influence of the latter on skeleton building in deep waters are discussed. Finally, the absence of sunlight and its relation to the sense organs, luminous organs and food supply of the deep-sea animals is dealt with at some length. The account, though brief, is carefully compiled, and is followed by an excellent series of note references, in which some of the questions brought forward in the text are more fully considered.

[1] Seeliger, O. *Tierleben der Tiefsee.* Leipzig, W. Engelmann, 1901. 49 pp., 1 Tafel.

Direction of Hair. — Students of general biology will be interested in Kidd's[1] studies on the direction of hair as evidence of the inheritance of an acquired character. The author points out that the hair slope of an individual may be modified during life. The hair streams of mammals are disposed in lines of least resistance, and yet are of so little importance to the animal that they cannot be regarded as produced by selection, — natural, sexual, or germinal. As they have arisen through the mechanical influence of the environment and have been handed on from generation to generation, they afford what the author believes to be a good example of the inheritance of acquired characters.

Alcyonaria of the Azores.[2] — The explorations of the *Hirondelle* about the Azores, the Gulf of Gascogne, and Terre Neuve brought to light thirty-eight species, of which nineteen were new. The Alcyonaria from the Azores are increased from six to twenty-nine, of which twelve were new, and the total for the Atlantic between Madeira and the arctic circle reaches one hundred and sixty-six. Six species found at the Azores have been taken in the West Indies or off the coasts of North America, which is about the same proportion of American species found among the mollusks of the Azores in the collections of the *Hirondelle*. The American species are all from depths below 500 meters, while those peculiar to the eastern parts of the Atlantic come mainly from levels above 400 meters. The abyssal forms are thus the only ones common to America and the Azores. The occurrence near the Azores of several species from the Mediterranean serves to emphasize still further the dependency of its fauna upon that of the Atlantic. The genus Calypterinus is rejected and its species transferred to Stachyodes, the supposed generic distinctions being due to a pathological condition caused by the presence of an annelid, one of the Eunicidæ, in a furrow of the trunk.

C. A. K.

Corals of the Pacific.[3] — The author finds that the corals of Hawaii and Laysan are principally Porites, Pollicipora, and Montipora. The

[1] Kidd, W. *Use-Inheritance illustrated by the Direction of Hair on the Bodies of Animals.* London, A. and C. Black, 1901. 47 pp.

[2] Studer, Th. Alcyonaires provenant des campagnes de l'*Hirondelle*, 1886–1888, *Result. des campagn. scient. Albert de Monaco*, fasc. 20, 1901. 4to, 64 pp., 11 pls.

[3] Studer, Th. Ergebnisse einer Reise nach dem Pacific (Schauinsland, 1896–1897), Madreporarier von Samoa, den Sandwich-Inseln und Laysan, *Zool. Jahrb.*, Abth. f. Syst., Bd. xiv (1901), pp. 388–428, Taf. XXV–XXXI.

Madrepores and Astræidæ common in more southerly waters and carried northward in the eastern Pacific by the Japan current do not characterize these northerly reefs of Hawaii and Laysan. The reef-building corals of this region show more affinity to those of lower California and the Mexican coast, to the Panamic fauna, due in the author's opinion to the weak westerly current in which the islands in question lie. This not only tends to establish Panamic influences here but prevents the access of the southern fauna, *e.g.*, the Madrepores. C. A. K.

The Lepidopterous Genus Depressaria. — The tineid moths of North America, owing to their great number, small size, and the difficulty of preserving them in good condition, have not received the attention they deserve. Yet there are few groups which offer such good opportunities for original research, our country being full of undescribed forms, many of interesting habits, remarkable form, or exquisite colors; while not a few are destructive to cultivated plants. Under these circumstances we rejoice to find that Mr. August Busck, of the Department of Agriculture, has taken up the study of these insects with remarkable energy and enthusiasm. Our pleasure in Mr. Busck's studies is the greater because the material he works upon is in our National Museum, where it can always be found and examined by the student. It is to be hoped that collectors in all parts of the country will contribute material and biological notes, all of which will be carefully acknowledged by Mr. Busck in publication, if we may judge of his methods by the paper before us. This paper (*Proc. U. S. National Museum*, Vol. XXIV, pp. 731–749) is a revision of the North American species of the genus Depressaria, of which thirty-nine are recognized as valid. It is not necessary in this place to enter upon any detailed discussion of the paper, but we may be permitted to point out that two of the specific names are wrongly spelled, owing to the erroneous spelling (so common among entomologists!) of the food plants from which the names are derived. *Depressaria psoraliella* Wlsm. (p. 740) should be *D. psoraleella*, the plant being Psoralea. *D. senicionella* Busck (p. 742) should be *D. senecionella*, the plant being Senecio. The food plant of *D. arnicella*, from Mt. Shasta, is said to be *A. angustifolia* (*i.e.*, *A. alpina*); but it seems that this species does not occur on Mt. Shasta, and the plant was more likely *A. longifolia* Eaton. T. D. A. C.

BOTANY.

A University Text-Book of Botany.[1] — Botany as taught to-day differs from the same subject as taught when many of the older teachers of to-day were students, more in its many-sidedness than in any other respect, — a result largely due to the publication and use of Sachs' text-book in the seventies, and of the translations, adaptations, and abridgments of that book that quickly followed its appearance. Since then numerous and in some cases excellent laboratory and reference books, prepared for elementary class or laboratory use or for students of special branches of the science, have been brought out, but no distinctly original comprehensive book of large size has appeared from an American author before this work by Professor Campbell.

In his preface the author clearly states his purpose to have been the preparation of a reference book, and not a laboratory manual, presenting in as compact a form as possible an outline of the essentials of modern botany and drawing its illustrations as far as possible from American material. A large part of the figures are original; and while, of necessity, anything like full references to the enormous literature of even the last few years have been impossible, each subject is provided with a short bibliography, opening the way to other references.

The book consists of fifteen chapters, headed: Introduction, The Plant Body, The Plant Cell, Classification, The Algæ, Fungi, The Archegoniatæ, Pteridophyta (two chapters), Spermatophyta (three chapters), Physiology, Relation to Environment, and Geological and Geographical Distribution. The treatment is interesting and direct, yet conservative in debatable matters, and half-tone plates scattered through the text, representing types of vegetation and plant societies, add much to the effectiveness of the ample illustration. W. T.

The Cyclopedia of American Horticulture.[2] — In the summer of 1900 the first volume of this large and comprehensive work was put

[1] Campbell, D. H. *A University Text-Book of Botany.* New York, The Macmillan Company, 1902. xv + 579 pp., 15 pls., 493 figs.

[2] Bailey, L. H., and Miller, W. *Cyclopedia of American Horticulture.* Comprising suggestions for cultivation of horticultural plants, descriptions of the species of fruits, vegetables, flowers, and ornamental plants sold in the United States and Canada, together with geographical and biographical sketches. Illustrated with over 2000 original engravings. In four volumes. New York, The Macmillan Company, 1900–1902. $20.

in the hands of subscribers, and the early spring of 1902 sees the concluding volume in print. What has been said earlier in the *Naturalist* about the quality of the first three volumes applies equally well to the one now issued. Whether the work be consulted by the gardener for cultural methods, by the amateur for the names of cultivated plants, or by the schoolmaster for information as to the horticultural resources and possibilities of a given state or territory, it will be found to offer a ready answer to most questions and to indicate how the more obscure ones may be answered by one having the patience to follow them up. Throughout the *Cyclopedia* the personality of its editor is manifest, although very many of the articles have been written by others; and perhaps the most interesting reading in it is the introduction to the fourth volume, in which, from his own pen, we learn how the work was conceived, planned, and executed. The *Cyclopedia* is a notable piece of book making, and it is gratifying to know that the editor hopes, by means of annual supplements, to round it out with analytical keys for the determination of genera, — which in the body of the work are alphabetically arranged, — an extended bibliography, and the current chronicles of horticultural change.

W. T.

Notes. — In the *Ottawa Naturalist* for April Professor Greene describes five new species of Ranunculus, from various parts of the United States and Canada.

In the *Botanical Gazette* for February Professor Sargent publishes a fourth paper on "New or Little-Known North American Trees," among which are several notable species of Cratægus and one of Prunus.

Prunus virginiana and *P. serotina*, as cultivated in France, are contrasted by Guinier in Nos. 1–2 of the current volume of the *Bulletin de la Société Botanique de France.*

The Lespedezas of Missouri are reviewed by Mackenzie and Bush in No. 2 of the current volume of *Transactions of the Academy of Science* of St. Louis.

Lieferungen 4, 5 of Schumann's "Blühende Kakteen" have appeared.

A voluminous study of *Cirsium arvense*, by Lund and Rostrup, with French abstract, has been published as Vol. X, No. 3, of the *Mémoires de l'Académie Royale des Sciences et des Lettres de Danemark.*

Professor Branner, who paid particular attention to palms while connected with the geological survey of Brazil, twenty or more years ago, and who then published an exhaustive account of the structure of the palm stem, has once more taken up his notes, and in the *Popular Science Monthly* for March gives a well-written illustrated account of the ecological and economic characteristics of the Brazilian palms.

No. 22 of the current series of "Contributions from the Gray Herbarium of Harvard University," constituting Vol. XXXVII, No. 17, of the *Proceedings of the American Academy of Arts and Sciences*, is by Mr. Fernald and deals with species of Carex.

A memoir on *Ustilago reiliana*, by Mottareale, has been separately issued from Vol. IV, fascicle 2, of the *Annali della R. Scuola Superiore d'Agricolture in Portici.*

Hefte 7, 8 of Engler's *Das Pflanzenreich* are devoted respectively to Naiadaceæ (by Rendle) and Aceraceæ (by Pax).

The fourth part, concluding Vol. I, and the second part of Vol. II, of the British Museum *Catalogue of the African Plants collected by Dr. Friederich Welwitsch in 1853–61* have been distributed by the trustees of the Museum.

Vol. III, Part III, of J. Medley Wood's *Natal Plants*, comprising Pls. CCLI to CCLXXV, inclusive, has recently been issued.

Vol. VII of the "Flore de France," by Rouy and Foucaud (continued by Rouy and Camus), constitutes the 1900 volume of the *Annales de l'Académie de La Rochelle*, recently issued. It extends from Rosaceæ to Cornaceæ.

Another of Dr. von Schrenk's important contributions to the economic study of mycology constitutes *Bulletin No. 14* of the Bureau of Plant Industry of the U. S. Department of Agriculture, and deals with the decay of timber and methods of preventing it. In addition to the results of his own study, the author includes a summary of the preventive results reached in Europe. As in his earlier papers, illustrations are both full and good.

A detailed account of the raising and manufacture of vanilla, by Lecomte and Chalot, is published from the press of Naud of Paris.

A paper on the Caoutchouc-yielding Landolphiaceæ, by Hua and Chevalier, is issued by Challamel of Paris.

If Mr. Wells's artist could have illustrated his hypothetical lunar landscapes from the vegetation of the central African "mountains of the moon," as figured by J. E. S. Moore in some cuts reproduced in *Nature* of January 23, he would have gained rather than lost in the uniqueness of the effect.

In *Forest Leaves* for February Professor Rothrock figures habit and bark of *Pyrus coronaria.*

An illustrated paper on Ochnaceæ, by Barteletti, is published in fascicle 4–6 of *Malpighia.*

Professor Greene publishes three new species of Senecio from British Columbia in the *Ottawa Naturalist* for February.

Liatris pycnostachya, as a garden plant, is illustrated in *Die Gartenwelt* of January 11.

The orchids of eastern Asia, as represented in the herbarium of the Muséum d'Histoire Naturelle, form the subject of an illustrated paper by Finet, in the *Revue générale de botanique* of December 15.

The conclusion of Spegazzini's "Stipeæ Platenses" constitutes No. 22, Vol. IV, of the *Anales del Museo Nacional de Montevideo.*

Fusicladium dendriticum is the subject of *Bulletin No. 67* of the Illinois Experiment Station, by Mr. Clinton. It is illustrated by a number of reproductions of photographs, and eleven pages are given to a full bibliography, — a feature as useful as it is unusual.

In the *Botanical Magazine* of Tokyo, No. 178, Vyeda has an illustrated paper on the "Benikoji fungus" of Formosa, — used in the production of a red fermented rice beverage.

Dr. Peglion publishes an article on the cereal Peronospora (*Sclerospora graminicola*) in *L'Italia Agricola* of January 15.

"The Algæ of Jamaica" is the title of a paper by F. S. Collins, published as Vol. XXXVII, No. 9, of the *Proceedings of the American Academy of Arts and Sciences.*

The life history of *Oscillaria prolifica* is sketched by Isabel F. Hyams and Ellen H. Richards in the *Technology Quarterly* of December.

An ecological study of the heath formations of northern Germany, by Graebner, constitutes Vol. V of Engler and Drude's *Die Vegetation der Erde*, and is the first of a series of volumes that are to deal with the plant formations of middle Europe. Though Germans

commonly use the word *Heide* in the sense of a wood, Graebner agrees with classic English usage in employing it for the open bushy formations characterized by Erica, Calluna, Empetrum, Juniper, etc.

Professor Selby, in the *Bulletin of the Torrey Botanical Club* for December, records another series of experiments with seeds subjected to the low temperature of liquid air, with the customary result that their viability appears not to be affected by even a forty-eight hours' sojourn at a temperature of $-190°$ C.

Dr. Goodale has a short note in the *American Journal of Science* for February on the memorial greenhouses at the Harvard Botanic Gardens and some of the physiological work being done in them.

The effects of water and of certain aqueous solutions on foliage are discussed by J. B. Dandeno in a lengthy and well-illustrated paper, reprinted from Vol. VII of the *Transactions of the Canadian Institute.*

The mapping of botanical data is discussed by Blanc in the *Bulletin de l'Herbier Boissier* of December 31.

A practical little handbook of greenhouse methods, that should be in possession of every "nature-study" teacher, is Green and Mackintosh's Outline of greenhouse laboratory work, issued as *Class Bulletin No. 12* of the Experiment Station of the University of Minnesota.

A paper by Mr. Chesnut on plants used by the Indians of Mendocino County, Cal., constitutes No. 3 of Vol. VII of *Contributions from the U. S. National Herbarium*, and contains numerous illustrations.

Lieferung VI of the new edition of Wiesner's *Rohstoffe des Pflanzenreiches*, issued in December, begins a consideration of economic woods and contains numerous illustrations of structural detail.

Vegetable powders and the means of knowing their composition by aid of the microscope are being treated by Greenish and Collin in current numbers of the *Pharmaceutical Journal.*

M. de Wildeman has recently distributed an account of late-producing Apocynaceæ, collected in the Congo country by Gentil.

The cause of white-topped meadow grasses in Finland is discussed by Reuter in Vol. XIX of *Acta societatis pro fauna et flora fennica*, and a bibliography of the subject is given.

Dr. White publishes a note on the use of *Solanum heterodoxum* in Mexico for the curdling of milk, in *Science* of December 13.

A long list of decorative plants hardy in South Dakota is given by Mr. Hansen in *Bulletin No. 72* of the experiment station located at Brookings.

An interesting illustrated article on rattan and its preparation for the market, by Preyer, is published in *Der Tropenpflanzer* for January.

In *Bulletin No. 6*, dealing with Capsicums, by Mr. Tracy, the Bureau of Plant Industry of the U. S. Department of Agriculture begins the publication of a series of catalogues of the trade names of American vegetables.

In the concluding fascicle of Vol. XIV of the eighth series of the *Annales des sciences naturelles, botanique*, M. Van Tieghem sums up the results of his studies on the ovule as a basis of classification in the flowering plants, giving at the end a résumé of the vegetable kingdom classified on this basis.

Dalla Torre and Harms' *Genera Siphonojamarum* in the fourth fascicle reaches the genus Cochleanthera of the Guttiferæ.

Engler and Prantl's *Die natürlichen Pflanzenfamilien* in Lieferung 211 reaches Isoetaceæ among the pteridophytes and in Lieferung 212, Pottiaceæ among the bryophytes.

An account of the dates at which the parts of Elliott's *Botany of South Carolina and Georgia* were issued is contributed to the December *Bulletin of the Torrey Botanical Club* by Barnhart.

The double fascicles 14–15 and 16–17 of Ascherson and Graebner's *Synopsis der Mitteleuropäischen Flora* deal respectively with Rosaceæ (in part) and Gramineæ (in part).

In Coste's *Flore descriptive et illustrée de la France*, the second volume of which is now in course of publication by Klincksieck of Paris, the description of each species is accompanied by an excellent small cut, showing habit and often essential detail.

An anatomical study of Hippocrateaceæ, connected with the occurrence of caoutchouc in that family, by Fritsch, occupies Heft 5 of Vol. XI of the *Beihefte zum botanischen Centralblatt.*

The aid afforded by calcium oxalate crystals in the identification of vegetable drugs is the subject of a paper by Kraemer in the *Journal of Pharmacology* for December.

The development, structure, and properties of the epidermis of certain dicotyledonous plants which persist for several years, forms the subject of a paper by Damm in Vol. XI, Heft 4, of the *Beihefte zum botanischen Centralblatt.*

Professor Heckel publishes, through the house of A. Challamel of Paris, a valuable paper on "Les graines grasses . . . des colonies françaises."

Part VII of Wiesner's *Rohstoffe des Pflanzenreiches*, appearing from the press of Wilhelm Engelmann of Leipzig, is devoted to fibers.

The pollination of *Solanum rostratum* and *Cassia chamæcrista*, both of which produce right- and left-handed flowers on the same plant, has been reinvestigated by Harris and Kuchs, whose paper is published in the February number of the *Kansas University Science Bulletin.* The earlier conclusions of Todd are not confirmed.

A paper by Haberlandt, entitled "Sinnesorgane im Pflanzenreich," issued from the Engelmann press of Leipzig, deals with irritable stamens, pistils, foliage leaves, insect traps, and tendrils.

A biographic sketch of Schimper, by Schenck, with portrait, has been separately printed from the *Berichte der deutschen botanischen Gesellschaft* for 1901.

A Eulogy of Unger, delivered in connection with the unveiling of the Unger bust at the Vienna University last July, has recently been distributed by Professor Wiesner, from the *Verhandlungen der k.k. zool.-bot. Gesellschaft in Wien.*

QUARTERLY RECORD OF GIFTS, APPOINTMENTS, RETIREMENTS, AND DEATHS.

EDUCATIONAL GIFTS.

Albion College, $21,000, from Gov. A. T. Bliss.

Adelphi College, Brooklyn, $125,000, from John D. Rockefeller; $125,000 from other donors.

Amherst College, $25,000, for the library, from Col. Mason W. Tyler; $65,000, from alumni and friends, for an observatory.

Bryn Mawr College, gifts amounting to $256,000, thus securing the conditional gift of $250,000 from John D. Rockefeller.

Columbia University, $50,000, from Mrs. Lena Currier.

Cornell University, $250,000, from John D. Rockefeller; $250,000, from other sources.

Dartmouth College, $32,500, by the will of F. W. Daniels.

Hamilton College, $5000, by the will of Prof. Anson Judd Upson.

Lick Observatory, $2500, from Mrs. Phœbe A. Hearst.

Massachusetts Institute of Technology, $5000 a year, for three years, for work in sanitary science.

Northwestern University, about $200,000, by the will of James F. Robinson.

Pennsylvania State College, $100,000, from Andrew Carnegie; $60,000, from Mr. and Mrs. C. M. Schwab; $20,000, from James G. White.

Radcliffe College, $5000, by the will of Mrs. Sarah A. Rand.

Rutgers College, $20,000, from F. M. and Ralph Vorhees.

Swarthmore College, a conditional gift of $100,000, from Isaac H. Clothier; $300,000, from other sources.

Smith College, $100,000, from various sources, securing the Rockefeller gift of the same amount.

University of California, $20,000, from Mrs. Phœbe Hearst: $5000, from Henry Weinstock; $8000, from Dr. M. Herzstein; $50,000, from D. O. Mills; $30,000, from other sources.

University of Pennsylvania, $300,000, from Joseph Wharton, for the school of finance; $100,000, for new buildings, from an anonymous donor.

University of Vermont, $6000, from Dr. Seward Webb, for the purchase of the Pringle herbarium.

Union College, $40,000, from Andrew Carnegie; $125,000, by compromise, from the estate of Thomas Armstrong.

Vassar College, a library building, from an anonymous donor.

Wells College, $50,000, from Henry A. Morgan; $25,000, from N. L. Zabriskie.

Wesleyan University, $75,000, from Charles Scott, Sr. and Jr., for a physical laboratory; $75,000, from an anonymous donor.

Western Reserve University, $100,000, from A. A. Pope.

Yale University, the residue of the estate of Edward W. Southworth, estimated at $200,000 to $300,000; a chemical building, costing, with the land, $96,000, from Mrs. Thomas G. Bennet; a building for the geological department, from an anonymous donor.

APPOINTMENTS.

Dr. Florentino Ameghino, director of the National Museum of Buenos Aires. — A. P. Anderson, curator of the herbarium of Columbia University. — J. H. Bair, assistant in anthropology in Barnard College. — Dr. F. A. Bather, assistant keeper in the department of geology in the British Museum. — Dr. A. N. Berlesi, assistant professor of plant pathology in the university at Milan. — Dr. Robert S. Breed, professor of biology and geology in Alleghany College. — Jean A. Brodhurst, assistant in botany in Barnard College. — Dr. R. E. Buffington, assistant in histology in Columbia University. — Dr. F. Carara, assistant professor of botany in the university at Catania. — Dr. D. Carazzi, assistant professor of zoölogy in the university at Sassari. — Dr. Adolf Cluss, professor of bacteriology in the university at Halle. — Dr. W. C. Coker, associate professor of botany in the University of North Carolina. — Dr. Carl Erich Correns, professor extraordinary of botany in the university at Leipzig. — Arthur L. Dean, assistant in plant physiology in Yale University. — Dr. R. B. Dixon, instructor in anthropology in Harvard University. — Dr. J. E. Duerden, interim professor of zoölogy in the University of North Carolina. — Dr. B. M. Duggar, professor of botany in the University of Missouri. — Dr. A. Fischer, professor of botany in the university at Basel. — Dr. P. A. Fish, professor of physiology and pharmacology in Cornell University. — Dr. Fournier, professor of geology and mineralogy in the university at Besançon. — Professor F. Gräff, head of the mineralogical institute at Freiburg i. B. — Dr. Caswell Grau, associate in zoölogy in Johns Hopkins University. — Dr. Arthur W. Greeley, assistant professor of zoölogy in Washington University. — Dr. J. Henscher, professor extraordinary of parasitology in the university at Zürich. — Dr. William Hunter of London, government bacteriologist at Hongkong. — Dr. Giuseppe Jatta, docent for zoölogy in the university at Naples. — Dr. E. C. Jeffrey, assistant professor of vegetable morphology in Harvard University. — Herbert Stanley Jevons, lecturer in mineralogy in the University of Sydney, N.S.W. — Dr. B. F. Kingsbury, professor of human physiology in Cornell University. — Dr. Ludwig Koch, honorary professor of botany at Heidelberg. — Dr. Henry B. Kümmel, state geologist of New Jersey. — Ivey F. Lewis, assistant in biology in the University of North Carolina. — Haven Metcalf,

professor of botany in Clemson College. — Dr. P. Mingazzini, professor of zoölogy in the university at Messina. — Dr. F. W. Neger, professor of botany in the forestry school at Eisenach. — Dr. Russell B. Opitz, demonstrator in physiology in Columbia University. — Dr. Charles Palache, assistant professor of mineralogy at Harvard University. — Dr. Florence Peebles, assistant professor of biology in the Woman's College of Baltimore. — C. G. Pringle, keeper of the herbarium of the University of Vermont. — Dr. F. Raffaele, professor of zoölogy in the university at Palermo. — Hugh D. Reed, instructor in vertebrate zoölogy in Cornell University. — L. F. Rettiger, instructor in bacteriology in Yale University. — Ralph W. Richards, instructor in geology in Tufts College. — Dr. H. Ries, assistant professor of geology in Cornell University. — Dr. D. Rosa, professor of zoölogy in the university at Modena. — Dr. Rudolf Rosemann, professor of physiology in the university at Greifswald. — Dr. A. Russo, professor of zoölogy in the university at Catania. — Dr. Florence R. Sabin, assistant in anatomy in Johns Hopkins University. — Dr. D. Saccardo, assistant in the royal institute of plant pathology at Rome. — Camille Sauvageau, professor of botany at Bordeaux. — Dr. Victor Schiffner, professor extraordinary of botany in the university at Munich. — Dr. R. J. Schubert, assistant on the Austrian Geological Survey. — Dr. George B. Shattuck, associate professor of physiographic geology in Johns Hopkins University. — Dr. Yngve Sjöstedt, custodian of the entomological collections at Stockholm. — Dr. Hans Soledever, professor of botany in the university at Erlangen. — Dr. R. M. Strong, interim professor of zoölogy in Haverford College. — Dr. Albert R. Sweetser, professor of biology in the University of Oregon. — Dr. G. B. de Toni, professor of botany in the university at Sassari, Sardinia. — Dr. Karl von Tubeuf, professor of forestry in the university at Munich. — Dr. Frank R. Van Horn, professor of geology at the Case School of Applied Science at Cleveland. — Dr. L. Waager, assistant on the Austrian Geological Survey. — Dr. Adolf Wagner, docent for botany in the university at Innsbruck. — William A. Willard, instructor in zoölogy in the University of Nebraska. — Dr. I. Wendell Williston, head professor of paleontology in the University of Chicago. — Dr. Alfred W. G. Wilson, demonstrator in geology in McGill University. — Dr. E. Zacharias, director of the Hamburg City Institute of Botany. — J. V. Zelizko, assistant in the museum of the Austrian Geological Survey. — Dr. Carl Zimmer, custodian of the zoölogical institute and museum in Breslau. — Professor R. A. Zimmermann, botanist to the biological station at Tanga, German East Africa.

RETIRED.

Dr. Max von Vintschgau from the chair of physiology in the university at Innsbruck.

DEATHS

Sergius Alpheraky, Russian entomologist. — Prof. Ernst von Ballion, entomologist, at Novorossiisk, Russia, Sept. 9, 1901, aged 84. — Dr. C. Berg, director of the National Museum in Buenos Aires, and a well-known zoölogist, January 19. — Dr. Alexander Bittner, head geologist of the Austrian Geological Survey in Vienna, April 1. — Dr. Hans Buchner, professor of bacteriology in the university at Munich, April 5, aged 51. — Stanislaus Clément, zoölogist and former head of the museum at Nîmes, February 7, aged 73. — J. Ottoman Dietz, student of Coleoptera, in New York, December 25. — Henri Filhol, vertebrate paleontologist of the Paris Natural History Museum, April 28, aged 60. — Dr. Friederich Leopold Goltz, professor of physiology in the university at Strassburg, May 4, aged 68. — C. J. Emil Haglund, student of Hemiptera, at Lommaryd, Sweden, Dec. 9, 1901, aged 64. — Emil Holub, African traveler and ornithologist, in Vienna, February 21, aged 55. — Dr. Joseph Kriechbaumer, student of Hymenoptera, in Munich, May 2. — T. J. Léger, professor of botany in the university at Caen, aged 36. — Alonzo Linn, bryologist in Jefferson College, Washington, Pa., Sept. 28, 1901. — Dr. Emil Adolf Lövendal, conservator of the zoölogical museum at Copenhagen, entomologist and skillful engraver on copper, July 6, 1901, aged 62. — J. C. Mausel-Pleydell, zoölogist, in Whatcombe, England, May 3, aged 84. — Carl Nehring, collector, in Piracicaba, Brazil, January 3. — Joseph Nolan, assistant on the geological survey of Ireland, in Dublin, April 19. — W. H. Penning of the geological survey of the United Kingdom, in London, April 20. — Andreas Reischet, naturalist and head of the Linz Museum, aged 55. — Dr. Carlo Riva, instructor in petrography in the university at Pavia, killed by an avalanche on Monte Grigna, June 3. — Baron Friedrich Rosen, professor of mineralogy in the university at Kazan, aged 68. — Dr. Richard Burton Rowe of the U.S. Geological Survey, at Los Angeles, Cal., May 26, aged 30. — Dr. Ferdinand Sommer, formerly professor of anatomy at Greifswald, aged 74. — Baron E. von Tröltsch, archæologist of Würtemburg, June 29, 1901, aged 73.

(No. 427 was mailed July 15.)

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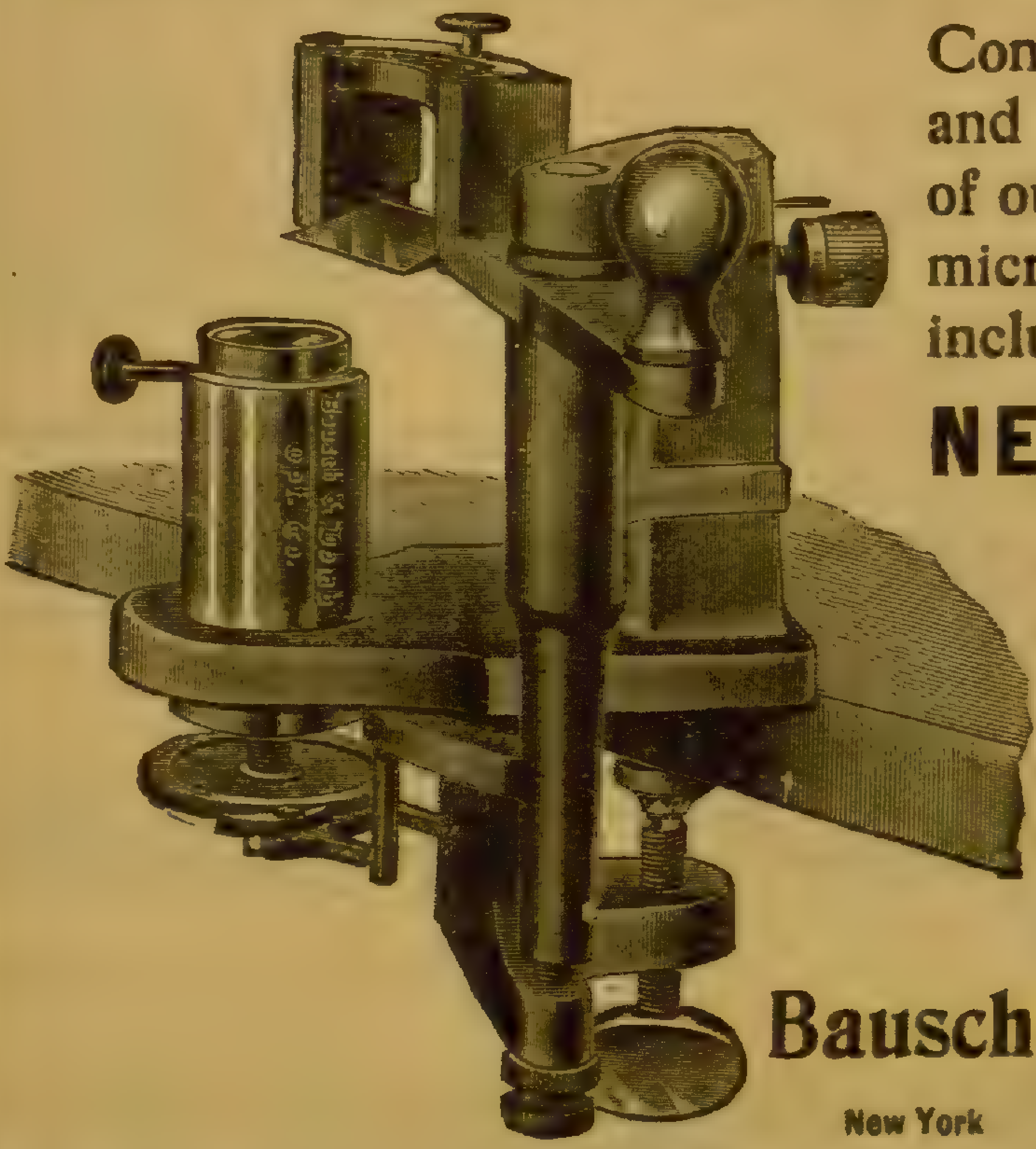

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THE AMERICAN NATURALIST

A MONTHLY JOURNAL
DEVOTED TO THE NATURAL SCIENCES
IN THEIR WIDEST SENSE

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All naturalists who have anything interesting to say are invited to send in their contributions, but the editors will endeavor to select for publication only that which is of truly scientific value and at the same time written so as to be intelligible, instructive, and interesting to the general scientific reader.

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THE

AMERICAN NATURALIST

Vol. XXXVI. *September, 1902.* No. 429.

THE DEVELOPMENT AND HOMOLOGIES OF THE MOUTH PARTS OF INSECTS.

VERNON L. KELLOGG.

The problem of the homologies of the mouth parts of insects is one long worked at by zoölogists. Since Savigny's first statement in 1816 of his conclusions regarding the homologies of the arthropod appendages, this problem has been a favorite one with insect morphologists, and in this century of work much has been accomplished. There is a practically complete agreement as to the homologies of the parts of the biting mouth as this mouth is variously composed in the Orthoptera, Coleoptera, Neuroptera, *et al.*, and a fair agreement obtains with regard to the interpretation of the homologies of some of the more modified kinds of mouth parts possessed by the piercing and sucking insects. This is true especially of those insects, like the Hymenoptera and the Lepidoptera, among which there are generalized forms showing the essential biting type (as with the sawflies among the Hymenoptera and Eriocephala and Micropteryx among the Lepidoptera), together with a series of gradatory forms leading plainly up to the highly specialized conditions exhibited by the higher members of these orders.

These homology-determinations were first made by a study of the comparative anatomy of the fully developed mouth parts (those of adult insects), and indeed have a fairly safe grounding on this comparative anatomical study alone. But with the development of embryological studies of insects came the confirmation of these determinations, or some of them, by the study of the development of the mouth parts. From their origin as budding appendages, arising on the successive segments of the embryonic head, their development has been readily and certainly traced to the definitive mouth-part condition ; and mandibles, maxillæ, and labium are as certainly serially homologous with each other and with the legs and antennæ as are the more obviously homologous segmental appendages of the crustaceans.

But this ontogenic development of the insectean mouth parts, simple and continuous as it is in the case of insects with an incomplete metamorphosis, is a very complex and difficult subject of study in all of those insects which undergo what is termed a complete metamorphosis, and this for the reason, now familiar to entomologists, that in the late larval and early pupal life of such insects a more or less radical histolysis, or breaking down of the larval organs and tissues, occurs, with a building up of the imaginal organs from small, primitive centers called histoblasts (imaginal disks), which are not derived from the corresponding larval organs but (for the appendages as legs and mouth parts) from the larval derm or cellular skin layer. Thus we have in the development of the mouth parts of insects with complete metamorphosis a discontinuity which sadly interferes with the determination of homologies by ontogenetic study. Indeed, so serious has this obstacle proved that we have as yet practically no complete tracing through both embryonic and post-embryonic development of the growth and development of the mouth parts of any insect of complete metamorphosis. And they are, for the most part, precisely those insects of most radical post-embryonic metamorphosis which possess in adult condition the most highly modified and specialized mouth parts, and which present to us the most serious task in the interpretation of the mouth-part homologies. The Diptera, of course, best exemplify these conditions.

There is no special difficulty, outside of the general difficulties which the study of insect embryology commonly presents, in tracing from beginning up to completed larval condition the development of the mouth parts of insects with complete metamorphosis; and the homologies of these larval mouth parts with the mouth parts of adult insects with incomplete metamorphosis can accordingly be determined on a basis of ontogenic study (also, of course, on a basis of comparative anatomy). The biting mouth parts of the more generalized flies, of the lepidopterous caterpillars and coleopterous grubs, can be homologized with the mandibles, maxillæ, and labium of the adult cockroaches and locusts, constituting the generalized biting or so-called orthopterous mouth. But when the attempt is made to carry the homologies on to the adult piercing and sucking mouths of the flies and butterflies we lose in the prepupal stage our grip on the continuity of embryonic and adult mouth conditions and find ourselves forced to rest our interpretation of the homologies of the adult dipterous, lepidopterous, and hymenopterous mouth on the basis of comparative anatomical studies. And fortunately for us the persistence of certain generalized forms already referred to enables us to make a pretty secure determination of these homologies for all of the orders except the Diptera. To my mind, indeed, the study of the comparative anatomy of the mouth parts of the generalized flies (families of the Nematocera) enables us to be pretty certain even in that order, but such an attempt[1] of mine in 1899 has certainly failed to be convincing to several entomologists.

There is necessary, then, the completion of the tracing of the development of the mouth parts; nothing less, under the circumstances that the most generalized of dipterous mouths are not at all generalized (if one may be so paradoxical), but are so specialized that no safe determination of the homologies can be made on the basis of comparative anatomy, — nothing less will be convincing or satisfactory for the solid grounding of an interpretation of the homologies of the mouth parts of

[1] The Mouth Parts of the Nematocerous Diptera, *Psyche*, vol. viii (1899): I, pp. 303–306, January; II, pp. 327–330, March; III, pp. 346–348, April; IV, pp. 355–359, May; V, pp. 363–365, June; with 11 figs.

the Diptera, and if this tracing can be effected for the other orders of holometabolous insects, it will put the homology-determinations on a much better foundation than they now have. It is the beginnings of such an attempt that is outlined in this paper.

NEUROPTERA.

The Neuroptera belong to the holometabolous insects, *i.e.*, insects with complete metamorphosis, but this metamorphosis in many forms is of a very simple and straightforward kind as compared with the radical metamorphosis of a fly or butterfly, for example. The mouth parts of the adult insect are, too, of the orthopterous or biting type, and there is no question regarding the interpretation of the mouth-part homologies. Mandibles, maxillæ, and labium of the neuropterous mouth are obviously homologous with the similarly named parts of the orthopterous mouth. Furthermore, the differences between the larval and adult mouth parts are comparatively slight, and no question is made regarding the homologies between the two sets. Yet it is worth while to trace the development of the imaginal parts in its more conspicuous features, and get a first sight at the relation between larval and imaginal mouth parts in a holometabolous insect. This relation is readily made out in the large and familiar neuropteron called the "dobson fly," or "hellgrammite," *Corydalis cornuta.*

FIG. 1. — Dorsal aspect of head of larva of *Corydalis cornuta*, with labrum removed. *lb.*, labrum; *md.*, mandible; *mx.*, maxilla; *mx.p.*, maxillary palpus; *st.*, stipes; *ga.*, galea; *li.*, labium; *li.p.*, labial palpus; *ant.*, antenna.

Corydalis cornuta (Figs. 1–5).—The mouth parts of the larval Corydalis are shown in Fig. 1, and their orthopterous character, together with the details of the various parts, are so readily apparent that little description is needed. The mandibles (*md.*) are very heavy and long; the maxillæ (*mx.*) have a short proximal segment, cardo (not visible in the drawing),

and a usually elongate parallel-sided stipes (*st.*) bearing at its terminal extremity the much-reduced three-segmented palpus (*mx.p.*) and a still smaller two-segmented terminal lobe, or galea (*ga.*), the lacinia being wholly wanting; the labium (*li.*) has the glossæ (*gl.*) (inner terminal lobes) fused but emarginate, the paraglossæ (outer terminal lobes) wanting, and the palpi (*li.p.*) three-segmented and well developed. The mouth parts are similar in both sexes.

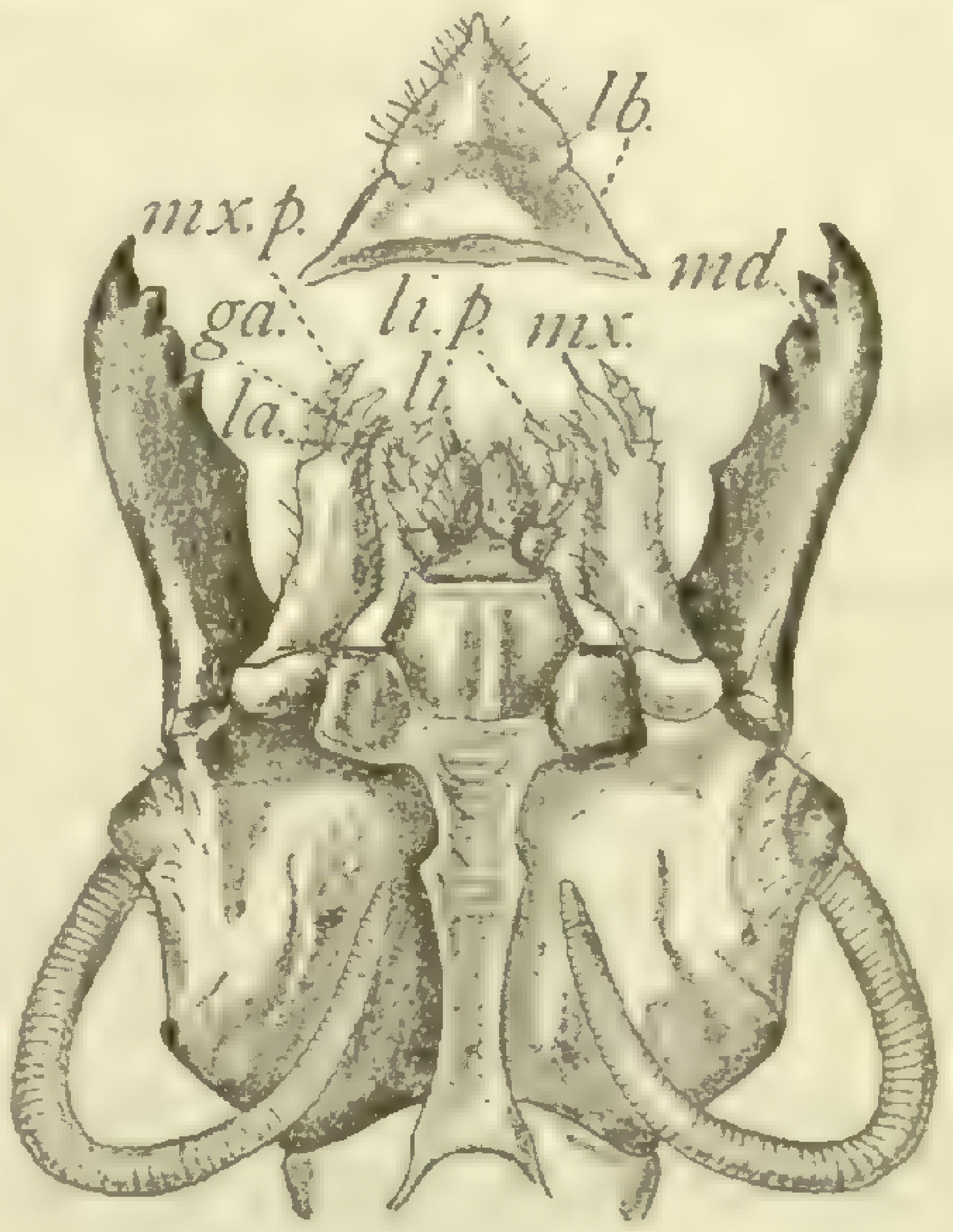

Fig. 2.—Ventral aspect of head of pupa of *Corydalis cornuta*. *lb.*, labrum; *md.*, mandible; *mx.*, maxilla; *mx.p.*, maxillary palpus; *ga.*, galea; *la.*, lacinia; *li.*, labium; *li.p.*, labial palpus.

Fig. 3.—**Dorsal aspect of head of old** larva of *Corydalis cornuta*, with body **wall of right side (in figure) dissected** away, showing pupal head beneath. *l.h.*, larval head wall; *l.md.*, larval mandible; *l.mx.*, larval maxilla; *l.li.*, larval labium; *l.ant.*, larval antenna; *p.h.*, wall of pupal head; *p.md.*, pupal mandible; *p.mx.*, pupal maxilla; *p.li.*, pupal labium; *p.ant.*, pupal antenna

When the larval dobson is ready to pupate (at the probable age of three years) it leaves the stream it has lived in, crawls under some stone near the water's edge, and changes into a quiet, non-feeding pupa, which, however, is not enclosed in a hard, opaque cuticle, but retains the power of violent wriggling, and bears the wing pads and legs only loosely appressed to the body. The mouth parts of the pupa (Fig. 2) show slight yet obvious differences from those of the larva (and also from those of the imago). The mandibles (*md.*) show a difference from the larval mandibles in the character of the dentation and in outline of the whole sclerite; the maxillæ have short, five-segmented palpi and two short terminal lobes, *i.e.*, both galea (*ga.*) and lacinia (*lc.*), and the labium (*li.*) has its free margin more emarginate and less truncate or blunt, the palpi (*li.p.*) remaining three-segmented.

If one dissects away the cuticle of the head of an old larva about to pupate, the pupal mouth parts will be found formed fairly within the old larval ones, and thus in perfect correspondence with them. Rather it would be truer to say that they are apparently the transformed larval parts minus the to-be-shed larval cuticle. This is shown in Fig. 3, in which the larval cuticle of the right-hand half of the head (including the whole of the labium) has been dissected away, exposing the

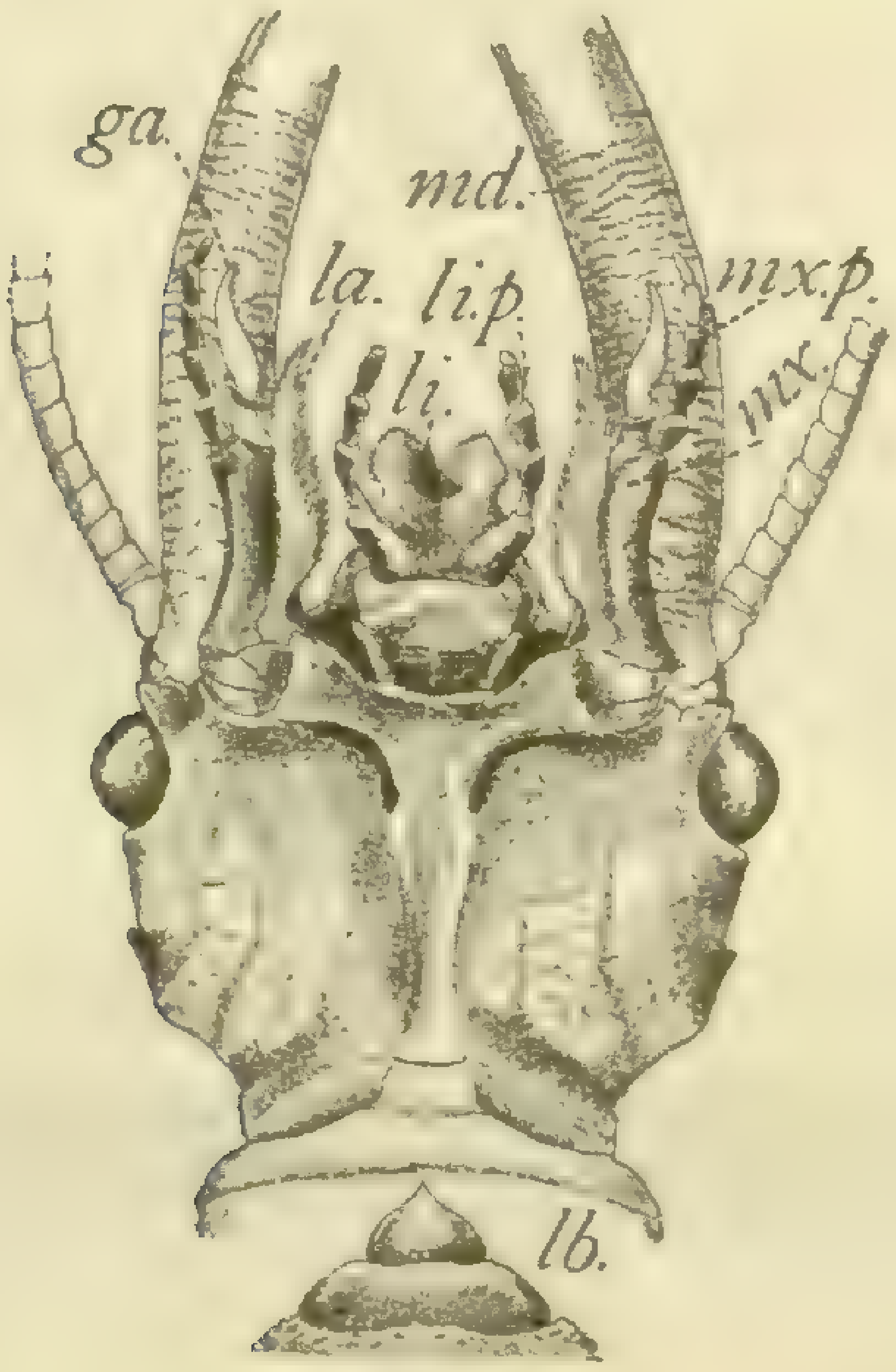

FIG. 4.

FIG. 5.

FIG. 4.—Ventral aspect of head of adult male *Corydalis cornuta*. *lb.*, labrum; *md.*, mandible; *mx.*, maxilla; *mx.p.*, maxillary palpus; *ga.*, galea; *la.*, lacinia; *li.*, labium; *li.p.*, labial palpus.

FIG. 5.—Ventral aspect of head of pupa of *Corydalis cornuta*, the pupal body wall being dissected away on right side (in figure), showing forming imaginal head and appendages. *p.md.*, pupal mandible; *p.mx.*, pupal maxilla; *p.li.*, pupal labium; *p.h.*, pupal body wall of head; *i.md.*, imaginal mandible; *i.mx.*, imaginal maxilla; *i.li.*, imaginal labium; *i.h.*, body wall of imaginal head.

still soft, unchitinized pupal cuticle, while the left side of the head is still wholly larval. From the right pupal mandible has been slipped the larval mandibular sheath, from the right pupal maxilla has been slipped the larval maxillar sheath, and from the whole pupal labium has been removed the larval covering. But the slight changes in outline and character of the pupal mouth parts are plainly apparent, while the identity of larval and pupal mandibles, maxillæ, and labium is unmistakable. There is yet no apparent difference in the mouth parts of the sexes.

In the adult (Fig. 4) we find mouth parts still of simple orthopterous type, with parts plainly homologous with the various orthopterous parts, and also as plainly with the parts of its own larva and pupa; but in the male the familiar but extraordinary modification of the mandibles, converting them from biting and masticating organs into a pair of long, non-dentate, pointed, clasping organs (*md.*) for holding the female, attracts our special attention. But these organs are certainly mandibles; the maxillæ (*mx.*) and labium (*li.*), changed slightly to be still more thoroughly orthopterous in type, are in their own places, and no other mandibulate organs except the claspers are present. In the female the imaginal mandibles are of usual biting dentate type. To make sure of the mandibulate character of the long claspers we have but to dissect the head of an old pupa, as shown in Fig. 5. In this figure the pupal cuticle has been removed from the right-hand half of the head, while left intact on the left side. Removing the pupal labial cuticle, the imaginal labium, practically identical with the pupal one, is exposed, with the palpi shortened by "telescoping" but ready to expand to full length; within the pupal maxillar sheath the imaginal maxilla in its now thoroughly orthopterous character is found, and within the comparatively short, strongly dentate, pupal mandible is found,

Fig. 6. — Mouth parts of larva of *Anatis 15-punctata*. *md.*, mandible; *mx.*, maxilla; *mx.l.*, maxillar lobe; *mx.p.*, maxillary palpus; *li.*, labium; *li.p.*, labial palpus.

Fig. 7. — Mouth parts of adult *Anatis 15-punctata*. *md.*, mandible; *mx.*, maxilla; *mx.p.*, maxillary palpus; *ga.*, galea; *la.*, lacinia; *li.*, labium; *li.p.*, labial palpus.

strongly "telescoped," the strange adult mandible, with its lack of dentation, its pointed tip, and its great length (easily attained by extension of the longitudinally compressed organ as discovered within the pupal sheath). Thus the transformation of larval parts into pupal, and of pupal into imaginal, is obvious, and the homologies between larval and imaginal parts are firmly founded on ontogenic basis.

Coleoptera.

The Coleoptera, like the Neuroptera, have biting mouth parts in both larval and imaginal stages, but the differences are usually greater, and the general metamorphosis is on the whole more radical.

Anatis 15-punctata (Figs. 6–8). — The accompanying figures made from a study of the mouth parts of *Anatis 15-punctata* illustrate the relations between larval and imaginal mouth parts of a member of the order. The larvæ (Fig. 6) have strongly chitinized, sharp-toothed mandibles (*md.*), maxillæ (*mx.*) with single terminal lobe (*mx.l.*), rather large four-segmented palpus (*mx.p.*), and fleshy liplike labium (*li.*), with fused terminal lobes and short one-segmented palpus (*li.p.*) inserted on a segment-like projection. In the adult (Fig. 7) the mandibles (*md.*) are shorter and heavier, the maxillæ (*mx.*) have both terminal lobes, galea (*ga.*) and lacinia (*lc.*), distinct, and four-segmented palpi (*mx.p.*), the distal segment being much broader than the others. The labium (*li.*) is rather elongate, with distinct basal sclerites (submentum and mentum), fused terminal lobes, and short three-segmented palpi (*li.p.*).

The small size of the larval head precludes such dissections as were easily made in the case of Corydalis, and the thickness and opacity of the chitinized cuticle of the head makes it impossible to clear specimens and study the forming imaginal head within, a method very successfully used in the cases of the honeybee and digger wasp (see *postea*). The development of the imaginal head and mouth parts had to be studied by means of sections, and here again the firmness of the head wall offered a serious obstacle to satisfactory work. I have

been able, however, to get series showing plainly the later steps of the development of the imaginal parts within the head of old larvæ. The developing imaginal parts, their definitive outlines already so strongly indicated as to make them recognizable (apart from their position), lie within the corresponding parts of the larval head (Fig. 8), imaginal mandibles with their tips within the larval mandibles, imaginal maxillæ with their two terminal lobes lying partly within and corresponding to the single terminal lobe of the larva, and imaginal palpi lying almost wholly within the larval palpi, and finally imaginal labium lying in the base of the larval labium. All of the forming imaginal parts are plainly seen to be folds or evaginations of the forming imaginal derm layer, which shows in sections as a continuous broad cellular line lying just underneath the larval integument.

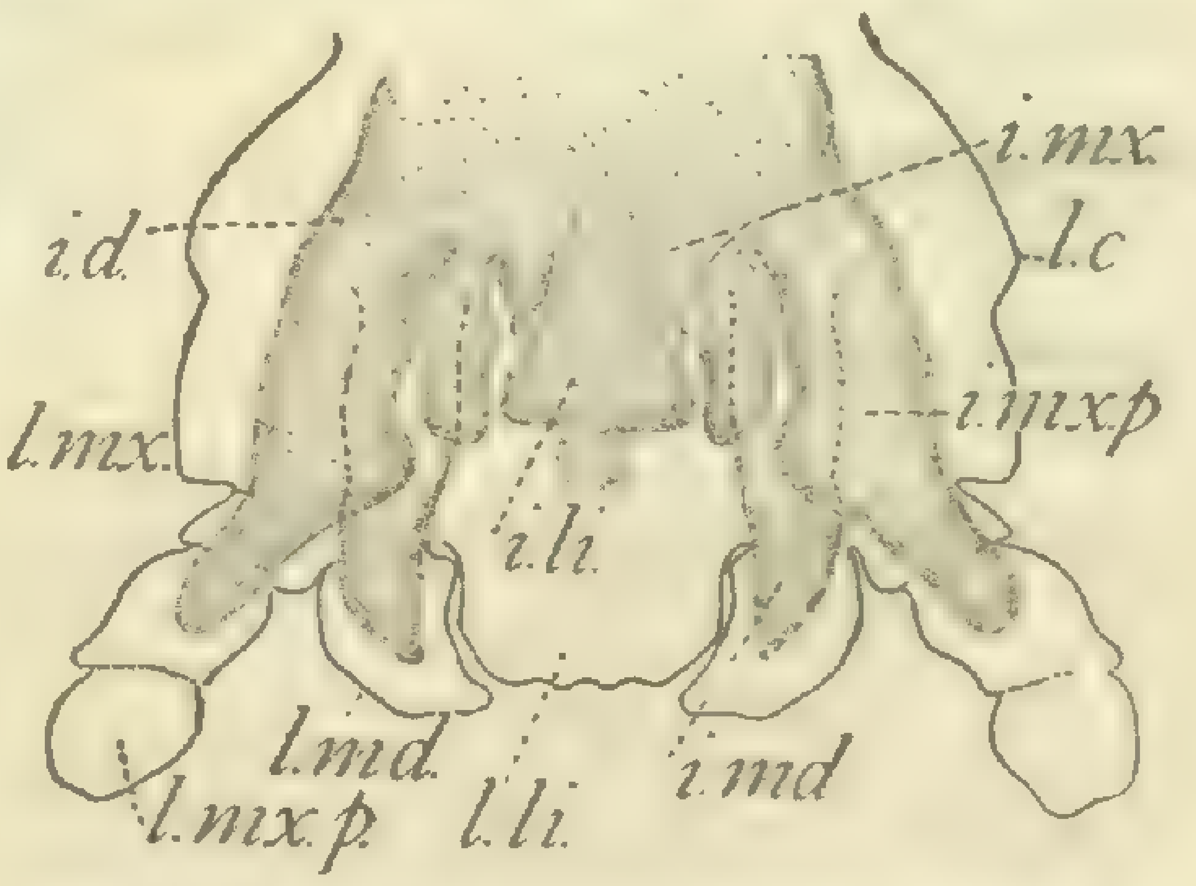

FIG. 8. — Semi-diagrammatic drawing of anterior portion of frontal horizontal section through the head of old larva of *Anatis 15-punctata* showing pupal (= imaginal) mouth parts forming underneath the larval integument. *l.c.*, larval cuticle; *i.d.*, imaginal derm; *l.md.*, larval mandible; *i.md.*, imaginal mandible; *l.mx.*, larval maxilla; *l.mx.p.*, larval maxillary palpus; *i.mx.*, imaginal maxilla; *i.mx.p.*, imaginal maxillary palpus; *l.li.*, larval labium; *i.li.*, imaginal labium.

Thus in Anatis we have practically the same conditions of development of the imaginal mouth parts within, and corresponding to, the larval mouth parts as we found in Corydalis.

LEPIDOPTERA.

Among the Lepidoptera we find a great range in degree of specialization of the mouth parts. In Eriocephala and Micropteryx, as described by Walter[1] and myself,[2] the mouth parts are really of the biting type, the mandibles being short, heavy, and dentate, true jaws, the maxillæ showing a cardo, stipes, short galea, and lacinia, and long six-segmented palpus, and the labium being liplike, with plainly distinguishable submentum

[1] Walter, A. Beiträge zur Morphologie der Schmetterlinge, *Jenaische Zeitschr. f. Naturwiss.*, vol. xviii (1885), pp. 751–807.

[2] Kellogg, V. L. The Mouth Parts of the Lepidoptera, *Amer. Nat.*, vol. v (1895), pp. 546–556, Pl. XXV.

and mentum and prominent three-segmented palpi. But in all the Lepidoptera above the Eriocephalidæ, Micropterygidæ, and Tineidæ, from a considerable to a very pronounced specialization is present, manifested by a complete reduction of the mandibles, by the reduction of the labium to a small rigid plate on the ventral side of the mouth bearing the persisting three-segmented palpi, and by a remarkable modification of the maxillæ whereby the galeæ (or laciniæ) are prolonged, grooved on their inner surfaces, and apposed to form the familiar sucking proboscis, while the other parts of the maxillæ are reduced and fused to form a rigid supporting base for the proboscis. In numerous moths no food is taken in the adult condition, and here the proboscis itself is reduced slightly or much, even to complete atrophy, and in extreme cases there is no mouth opening at all.

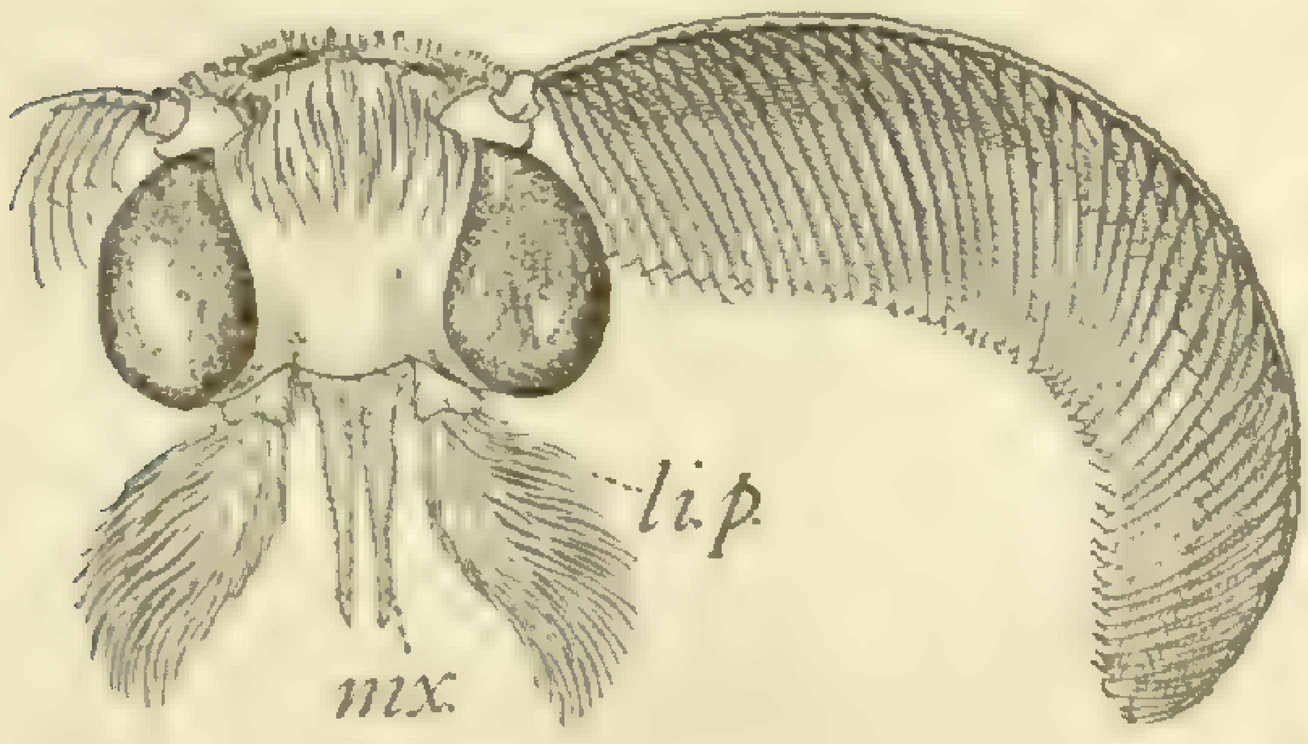

FIG. 9. — Frontal aspect of head of imago of *Notolophus leucostigma*. *mx.*, maxilla; *li.p.*, labial palpus.

Notolophus leucostigma (Figs. 9–12). — In the white-marked tussock moth, *Notolophus leucostigma*, the mouth parts (Fig. 9) of the adult, although functionless, or at least apparently incapable of taking food, show all the usual parts peculiar to the typical specialized lepidopterous mouth. The labium is a small fixed plate, forming part of the ventral wall of the head and bearing the conspicuous hairy three-segmented palpi (*li.p.*); the maxillæ (*mx.*) are simply two slender tapering processes, the halves of the usual proboscis, but in this case not applied to each other and hence not forming a sucking tube; the maxillary palpi are wholly reduced, and the mandibles entirely wanting.

FIG. 10. — Frontal aspect of head of larva of *Notolophus leucostigma*. *ant.*, antenna; *md.*, mandible; *mx.*, maxilla; *mx.p.*, maxillary palpus; *li.*, labium.

In the caterpillar (Fig. 10) the biting mouth parts common to lepidopterous larvæ are present, with full complement of

distinct and readily recognizable mandibles (*md.*), maxillæ (*mx.*) with short but distinct three-segmented palpi (*mx.p.*), and labium (*li.*) with very small ex-articulate palpi.

If an old larva, nearly ready to pupate, be taken, and its head dissected, as illustrated in Fig. 11, it will be found that underneath, or within, the larval labium, or labial cuticle, will be found the forming imaginal labial palpi; within the larval maxilla will be found the forming imaginal maxillæ, while within the larval mandible will be found nothing at all. In Fig. 11 the larval cuticle of the left side of the head has been dissected away, showing this correspondence between larval and imaginal parts; the larval maxillary sheath has been slipped off of the forming imaginal maxillar process, while on that part of the forming imaginal head from which the larval mandible was taken there is not a trace even of a forming organ. Fig. 12 shows the entirely dissected-out pupal (equals subimaginal head), with the already unmistakably recognizable imaginal mouth parts.

Fig. 11. — Frontal aspect of head of old larva of *Notolophus leucostigma*, with body wall of left side (in figure) dissected away, showing pupal (= imaginal) head underneath. *l.ant.*, larval antenna; *l.md.*, larval mandible; *l.mx.*, larval maxilla; *l.li.*, larval labium; *lb.*, larval labrum; *ant.*, imaginal antenna; *i.mx.*, imaginal maxilla.

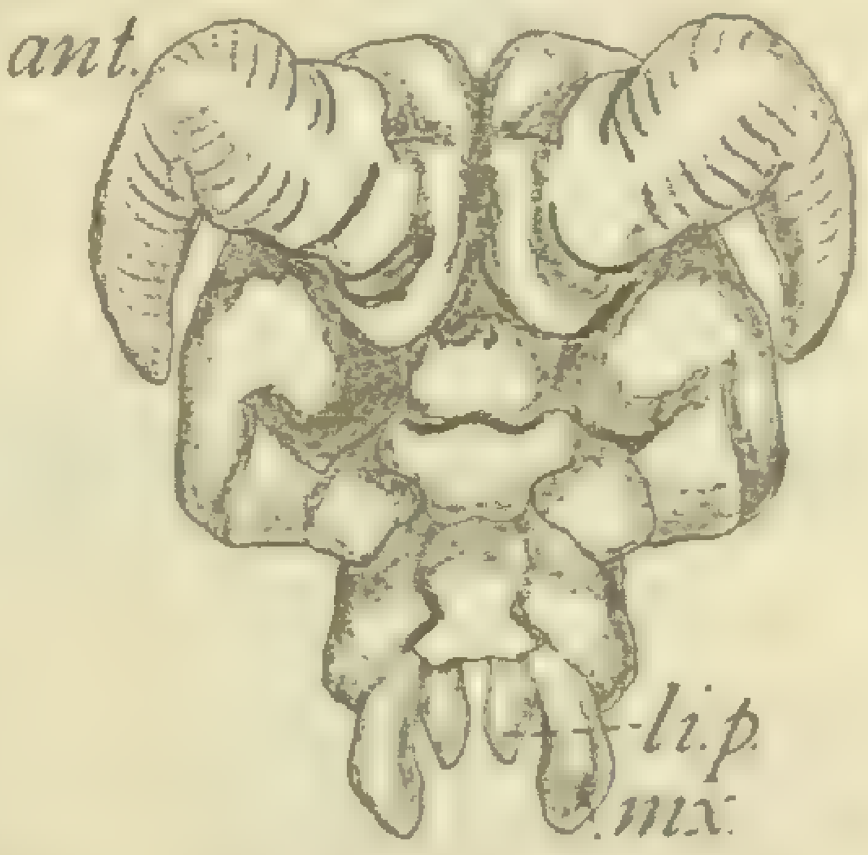

Fig. 12. — Pupal (= imaginal) head of *Notolophus leucostigma* dissected out of larval head. *mx.*, maxilla; *li.p.*, labial palpus; *ant.*, antenna.

Thus in this representative of the Lepidoptera we find the imaginal mouth parts developing in perfect correspondence with the larval parts, imaginal maxillæ within larval maxillæ, imaginal labium in larval labium, and within the well-developed larval mandibles *nothing*, with a corresponding total absence of mandibles in the fully developed moth. By sectioning the heads of old larvæ, it is readily perceivable that these developing imaginal mouth parts lying within and corresponding to the various larval parts are evaginations of the new or imaginal derm which forms a continuous layer underneath the

larval integument. Similarly, it is apparent that the imaginal antennæ and compound eyes are in the one case evaginations and in the other simply modified portions of this imaginal derm; and although I have not made cuttings of a complete series of heads from young to oldest larvæ, enough of the younger stages have been studied to show the simple dermal origin of all these parts by a continuous process of evagination and modification. We are sufficiently acquainted with the origin and mode of development of the legs and wings of insects from histoblasts to recognize in these histoblasts, or developmental centers, simple invaginations of the derm, which later become evaginations. Whether an organ, as wing, leg, antenna, or mouth part, shall begin as an invagination or an evagination of the derm is chiefly a matter of mechanical necessity or ease, and of degree of radicalness in the metamorphosis. In either case the ultimate origin, that of being simply a particular portion or area of derm, is the same; the invagination must become an evagination; the difference lies in the mechanical factors of the developmental process.

Hymenoptera.

In the order Hymenoptera there is to be found, as in the Lepidoptera, a wide range of degree of specialization of the mouth parts, varying from the biting, orthopterous mouth of the sawflies to the highly modified sucking mouth of the honey-bee; but throughout the order the mandibles persist in plainly jawlike character, and are always recognizable landmarks in mouth-part dissections. The only questions in the homology-interpretation occur in those cases where the labium and maxillæ are much modified and more or less completely fused or bound together. But these questions are not very serious; entomologists are fairly agreed, on a basis of comparative anatomical study, on the interpretation of the homologies of the hymenopterous mouth parts. But the results of a study of the post-embryonic development of the mouth parts, *i.e.*, the development of the imaginal mouth parts, undertaken by one of my students, Mr. M. H. Spaulding, illuminate too beautifully

and effectively the whole study of the development of imaginal mouth parts in holometabolous insects to be overlooked because of the lack of any crying need for an ontogenic confirmation of the hymenopterous homologies. Mr. Spaulding has been admirably successful in so clearing and staining the heads of variously aged larvæ of the honeybee and of a digger wasp, Ammophila *sp.*, that the developing imaginal head within the larval integument may be as easily studied as the exterior of the larval head itself. The bee and wasp larvæ, it will be recalled, are both "inside feeders," *i.e.*, lie during their life enclosed in a protecting cell, in one case of wax, in the other of hardened mud, and thus may and do dispense with the heavily chitinized opaque head cuticle common to exposed insect larvæ. And both larvæ have full complements of mouth parts, namely, mandibles, maxillæ, and labium, — a condition not common to all larvæ in those two orders, Hymenoptera and Diptera, in which the post-embryonic metamorphosis is most radical. This condition is a necessary one for the determination of the relations of the imaginal to the larval parts.

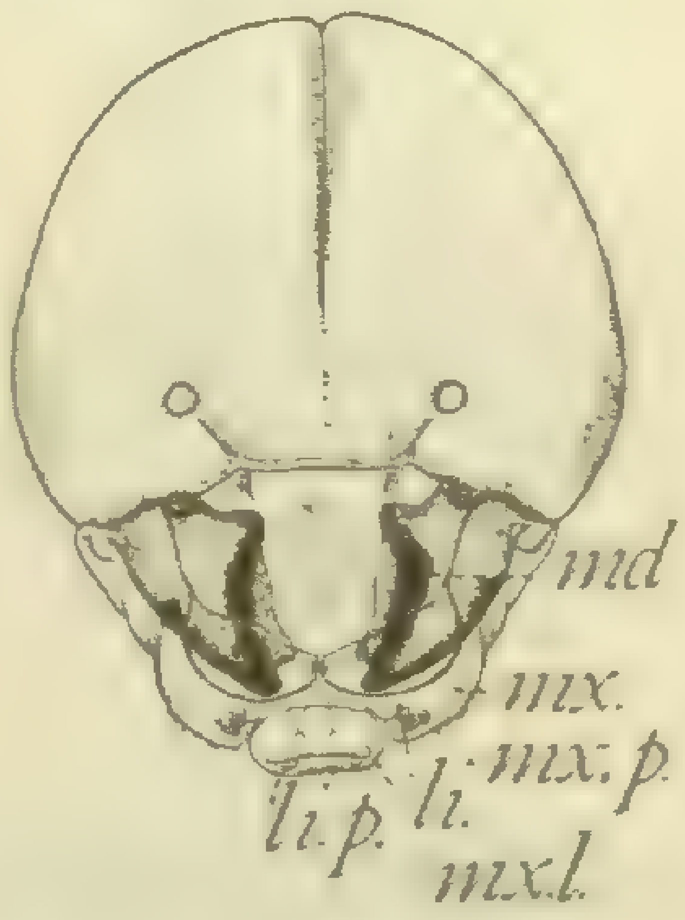

FIG. 13. — Frontal aspect of head of larva of digger wasp, *Ammophila* sp. *md.*, mandible; *mx.*, maxilla; *mx.p.*, maxillary palpus; *mx.l.*, maxillary lobe; *li.*, labium; *li.p.*, labial palpus.

Ammophila sp. (Figs. 13–15). — The larval mouth parts (Fig. 13) consist of well chitinized crushing mandibles (*md.*), short fleshy maxillæ (*mx.*) with very small one-segmented palpus (*mx.p.*) and smaller terminal lobe (*mx.l.*), and short liplike labium (*li.*) with pair of very small one-segmented palpi (*li.p.*). The adult wasp also has a complete complement of mouth parts (Fig. 14), all very elongate and slender, the mandibles (*md.*) heavily chitinized and toothed, the maxillæ (*mx.*) long and slender with distinct cardo and stipes, five-segmented palpus (*mx.p.*), and simple terminal lobe composed of the fused galea and lacinia, and the labium (*li.*) also long and narrow with fused submentum and mentum, four-segmented palpi (*li.p.*), slender ligula formed of the fused glossæ (*gl.*), and distinct slender paraglossæ (*p.g.*) less than half as long as the fused glossæ.

It is obvious that these long slender imaginal mouth parts cannot be contained within the very much shorter and altogether smaller larval parts. As a matter of fact, the whole imaginal head is for simple mechanical reasons forced to lie during its development chiefly in the anterior larval thoracic segment, the anterior portions, including the antennæ and mouth parts, projecting forward into the larval head capsule. But still there is indicated perfectly the correspondence between particular imaginal parts and particular larval parts

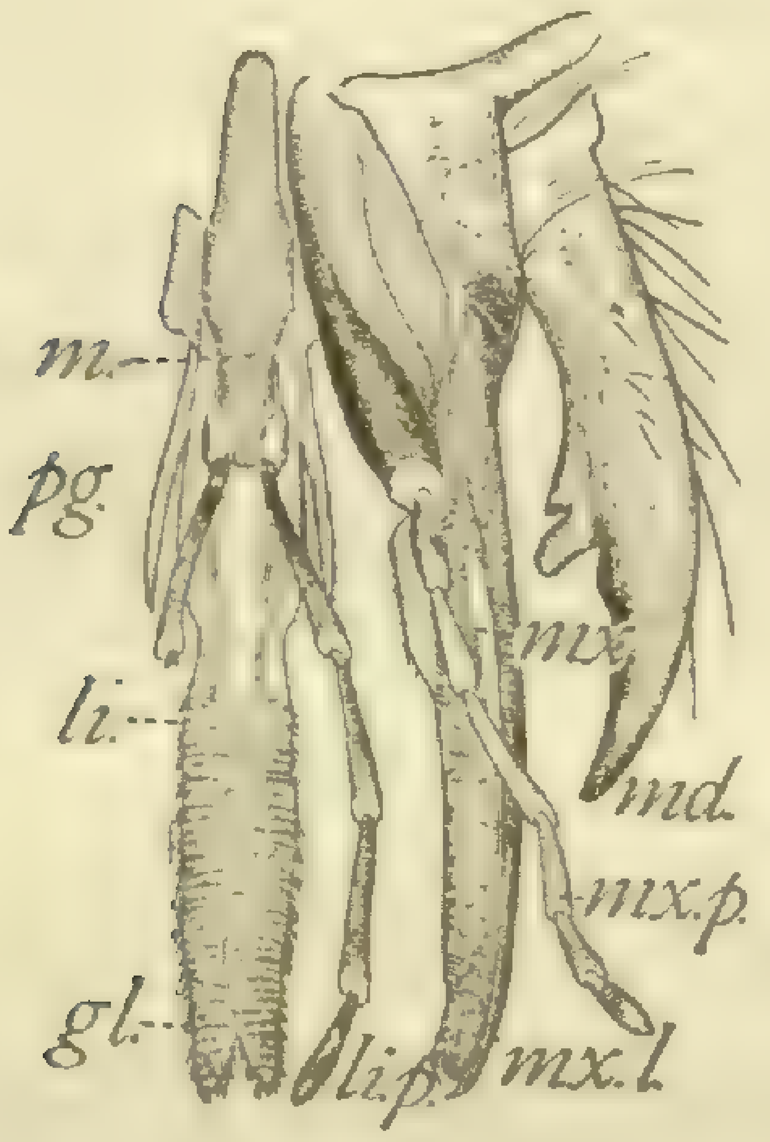

FIG. 14.

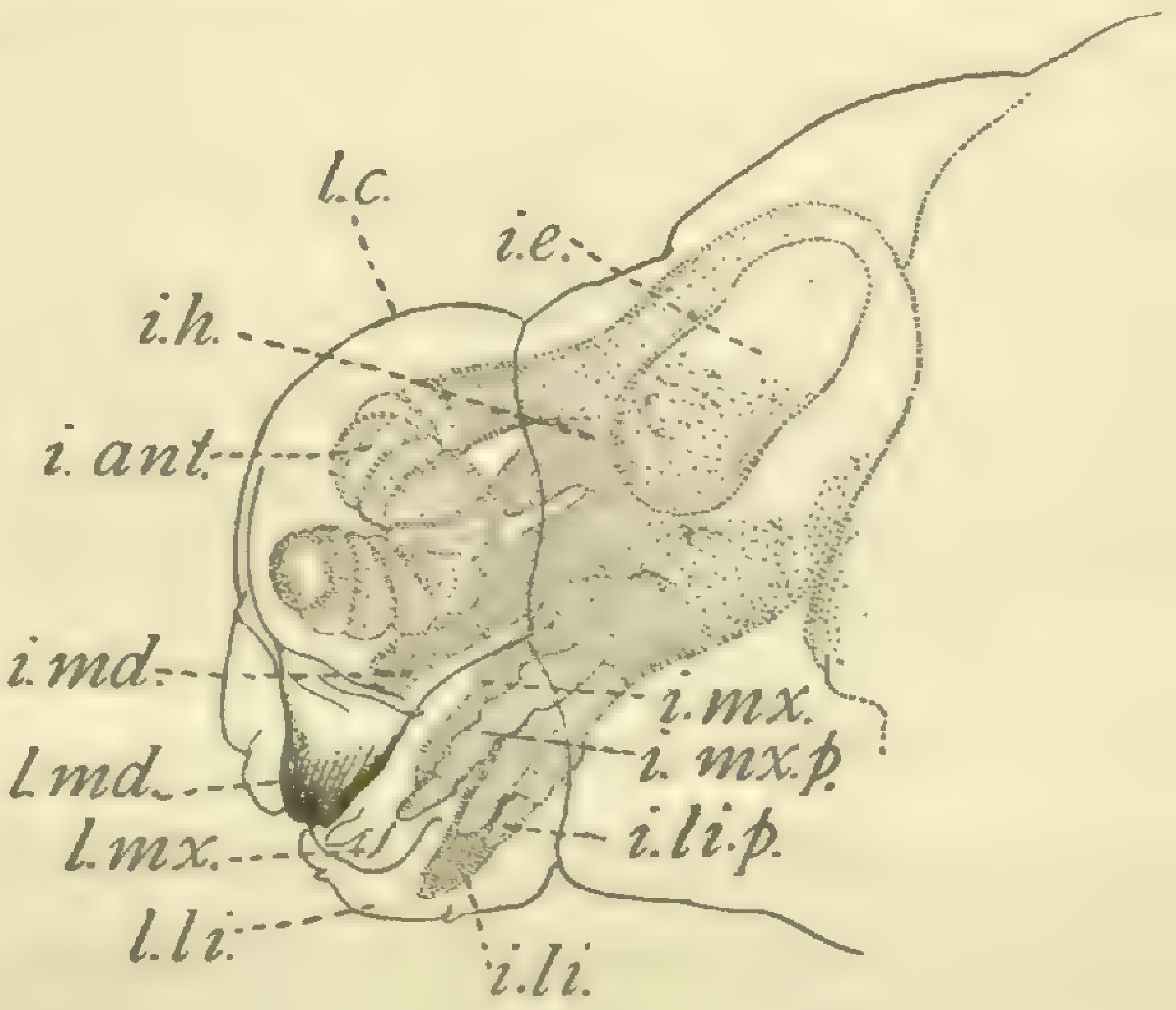

FIG. 15.

FIG. 14. — Mouth parts of adult digger wasp, *Ammophila* sp. (mandible, maxilla, and labial palpus of left side, in figure, not drawn). *md.*, mandible; *mx.*, maxilla; *mx.p.*, maxillary palpus; *mx.l.*, maxillary lobe; *li.*, labium; *li.p.*, labial palpus; *gl.*, glossæ; *pg.*, paraglossa; *m.*, mentum.

FIG. 15. — Head of old larva of digger wasp, *Ammophila* sp., cleared to show forming imaginal head within. *l.c.*, larval head wall; *i.h.*, forming imaginal head; *i.e.*, imaginal eye; *i.ant.*, imaginal antenna; *l.md.*, larval mandible; *i.md.*, imaginal mandible; *l.mx.*, larval maxilla; *i.mx.*, imaginal maxilla; *i.mx.p.*, imaginal maxillary palpus; *l.li.*, larval labium; *i.li.*, imaginal labium; *i.li.p.*, imaginal labial palpus.

by the fact that the projecting tips of the elongate imaginal parts penetrate or lie within the short larval parts. This is shown clearly in the cleared and stained heads prepared by Mr. Spaulding, as well as in series of sections. Fig. 15 is drawn with camera lucida from one of the whole head preparations, and, as indicated by the lettering, those parts of the imago which we have, on the basis of comparative anatomy, assumed to compose the labium, do project into and correspond with the larval labium; the case is similar with maxillæ and mandibles. But, in origin, these imaginal mouth parts arise as

dermal modifications and outgrowths which for simple demands of space become far removed from the larval mouth parts, the bases of the developing imaginal parts lying, indeed, in late larval life in the first thoracic larval segment. But in earlier larval life the beginning imaginal parts lie almost wholly within the larval parts, and no one studying the series of whole head preparations and of sections can fail to be convinced of the certain correspondence and homology between larval and imaginal parts, although there may be said to be no perfect transformation or development of the one into the other, the evidence being that of a correspondence in position on the head and of part for part.

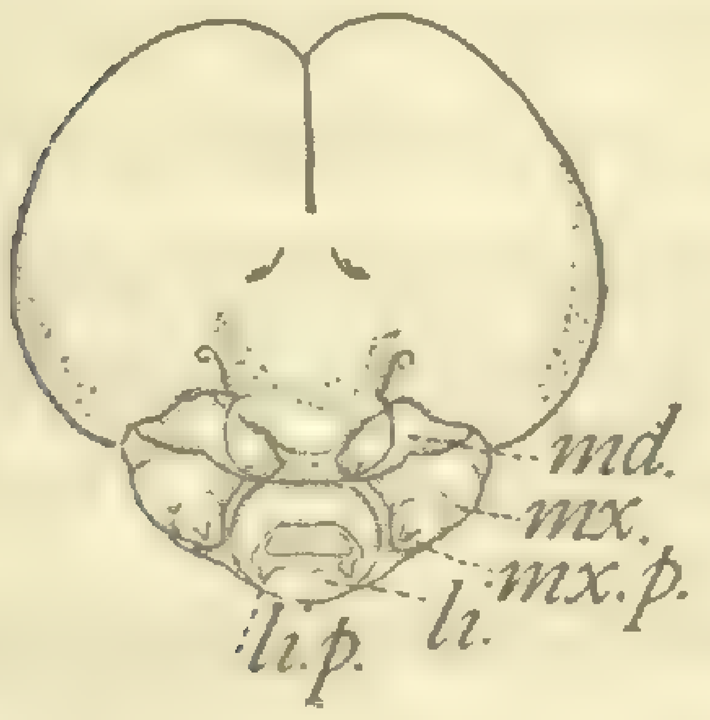

FIG. 16.—Frontal aspect of head of larva of honeybee, *Apis mellifica*. *md.*, mandible; *mx.*, maxilla; *mx.p.*, maxillary palpus; *li.*, labium; *li.p.*, labial palpus.

Apis mellifica (Figs. 16–18).—The beautiful series of cleared and stained heads of honeybee larvæ of different ages, and the series of sections of similar heads prepared by Mr. Spaulding, show a condition in the development of the imaginal mouth parts of the bee wholly identical with that just shown for the digger wasp. The larval mouth parts (Fig. 16) are very weakly chitinized, but are complete and readily distinguishable. They resemble in general the mouth parts of the digger wasp larva, but are smaller, weaker, and the short fleshy maxilla bears only the minute one-segmented palpus, having no tiny lobe as in the wasp maxilla. The imaginal mouth parts (Fig. 17) of the bee, familiar to all entomologists, are composed of horny, trowel-like mandibles (*md.*), long maxillæ (*mx.*) with cardo (*cd.*), stipes (*st.*), small one-segmented palpus (*mx.p.*), and with galea and lacinia fused to form a single flattened, pointed, bladelike terminal lobe (*mx.l.*), and of labium (*li.*) with long, tapering subcylindrical ligula formed

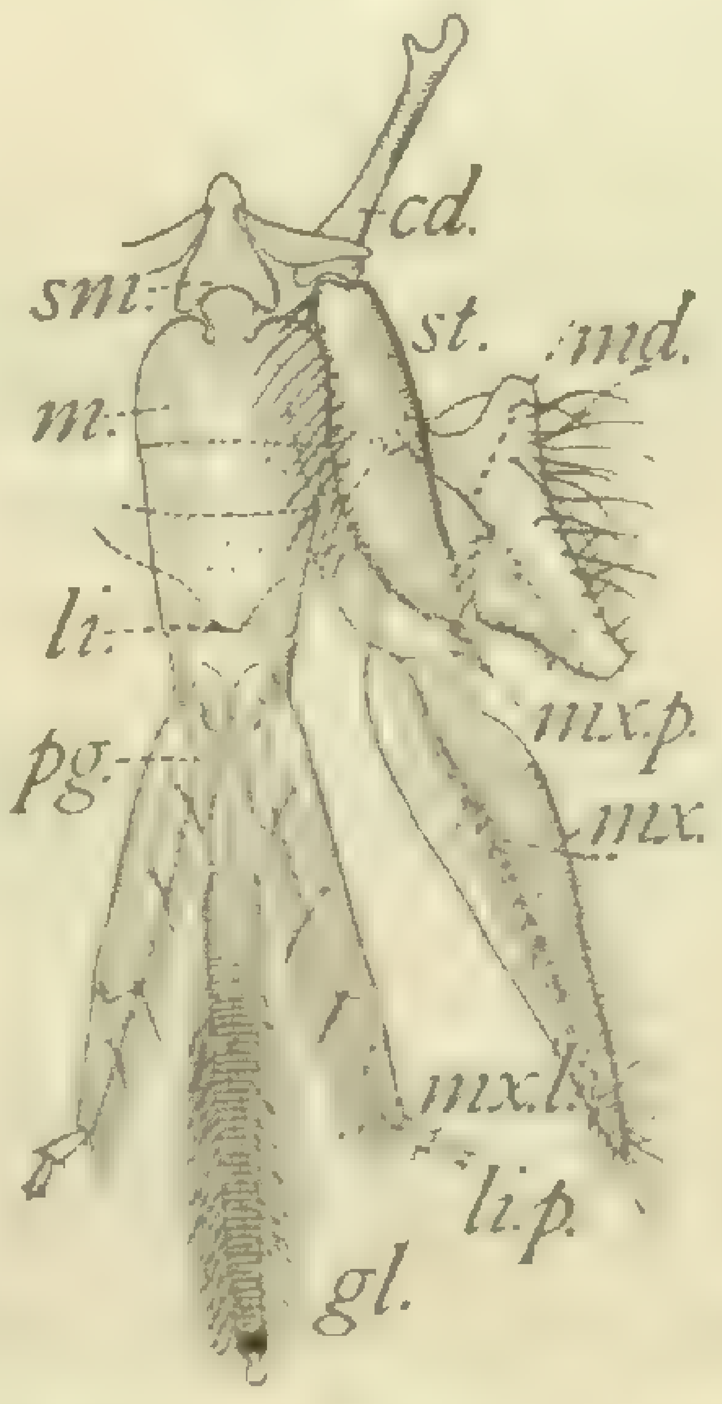

FIG. 17.—Mouth parts of adult honeybee, *Apis mellifica*. *md.*, mandible; *mx.*, maxilla; *mx.p.*, maxillary palpus; *mx.l.*, maxillary lobe; *st.*, stipes; *cd.*, cardo; *li.*, labium; *s.m.*, submentum; *m.*, mentum; *pg.*, paraglossa; *gl.*, glossa; *li.p.*, labial palpus.

of the fused glossæ (*gl.*), short but distinct flaplike paraglossæ (*pg.*), three-segmented palpi (*li.p.*) borne on a long palpiger, and at the base a distinct mentum (*m.*) and submentum (*sm.*).

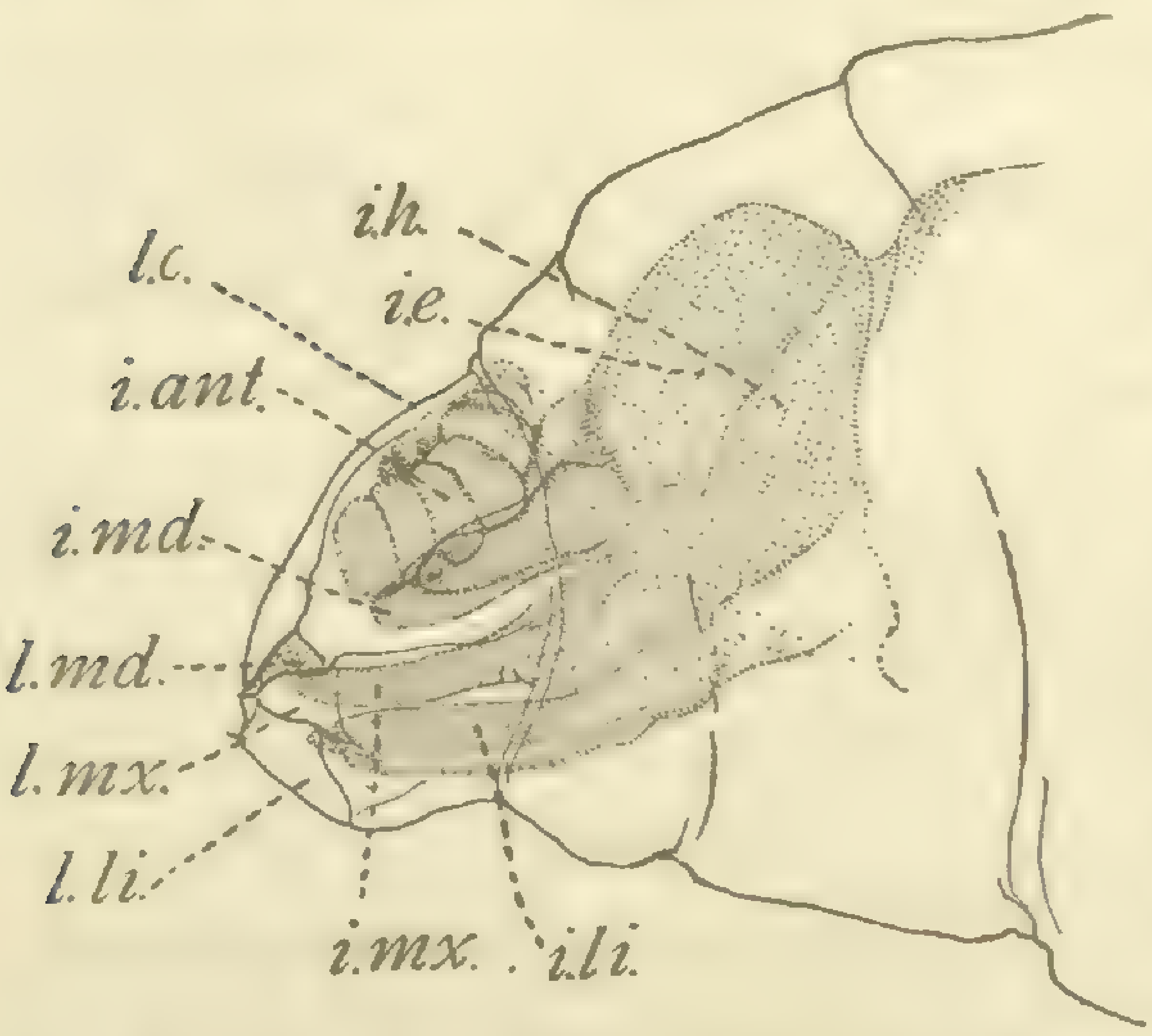

FIG. 18. — Head of old larva of honeybee, *Apis mellifica*, cleared to show forming imaginal head within. *l.c.*, larval head wall; *i.h.*, imaginal head; *i.e.*, imaginal eye; *i.ant.*, imaginal antenna; *l.md.*, larval mandible; *i.md.*, imaginal mandible; *l.mx.*, larval maxilla; *i.mx.*, imaginal maxilla; *l.li.*, larval labium; *i.li.*, imaginal labium.

As with the digger wasp, the developing head of the imago, with its long antennæ and mouth parts, demands more space than is afforded within the larval head segment, so that it is crowded backward and occupies part of the first and second larval thoracic segments. But the forming imaginal mouth parts are to be found with their tips projecting into the corresponding larval parts, as shown in Fig. 18. The conditions of the development of the imaginal parts, and of their perfect correspondence with the larval parts, are wholly like those already explained for the digger wasp.

DIPTERA.

In the case of the Diptera, — and it is here that the necessity of ontogenetic study is most important, indispensable indeed, for the determination of the homologies, — we have, as in the Hymenoptera and Lepidoptera, a great variety of mouth-part conditions culminating in the extreme specialization characteristic of the muscid forms. In most Diptera it is obvious that a total reduction of at least one pair of the buccal appendages has occurred, with a large reduction and complete modification of the remaining parts. From a considerable study of the anatomy of the fully developed mouth parts in a long series of dipterous forms, including representatives of all except one (the Ornephilidæ) of the nematocerous families, —

those families by common agreement held to constitute the more generalized portion of the order, — I came to the conclusion that the old and most widely, if perhaps uncritically, accepted interpretation of the homologies of the dipterous one is the true one. This interpretation homologizes the labella-bearing proboscis common to all the more specialized flies with the labium of other insects, finds the maxillæ represented in these specialized forms chiefly or only by a pair of palpi, and finds the mandibles wholly wanting in all but the females of a few families. In the case of most of the nematocerous families the labium retains a truly labiumlike character and has not developed the pseudotracheæ-bearing labella, while the maxillæ are represented by a well-developed bladelike terminal lobe as well as by the palpi. The mandibles when present are of the character of elongate blades or stylets, never of the character of true crushing or biting jaws. The structural character of the mouth in each of the nematocerous families is described and illustrated in my series of papers (1899) in *Psyche*, previously referred to.

But several interpretations of the homologies of the mouth parts widely at variance with the above have been offered. In these various interpretations the possession of mandibles by any flies at all is denied; the so-called labium is considered to be composed of modified parts of the maxillæ, and the so-called maxillæ are believed to be parts of the labium; in fact, most of the possible changes which an active speculation could invent have been rung on the theme. Nor are these interpretations based on mere speculation; they are the results, in several cases, of prolonged and disinterested examination of considerable series of specimens.

In the face of such differences of opinion, and with the apparent limits of the method of the comparative study of the fully developed mouth parts of various members of the order reached, it becomes imperative to seek the clue to these lost homologies in the facts of development. And this is really the first object of this present study. Can the homologies of the dipterous mouth parts be discovered by the study of the development of the parts?

For a complete developmental study of the mouth parts of any dipteron it would be necessary to begin with the budding appendages of the head segments in early embryonic life, to trace the development of these appendages to their definitive form in the hatched larva, and finally to follow the transformation, if it occurs, of these larval parts into the ultimate imaginal ones. As a matter of fact, such actual transformation does not occur, so that the study of the postembryonic development of the mouth parts consists of noting the ecdysis of the larval parts and determining the ontogenic relations of the new imaginal parts to the old larval ones.

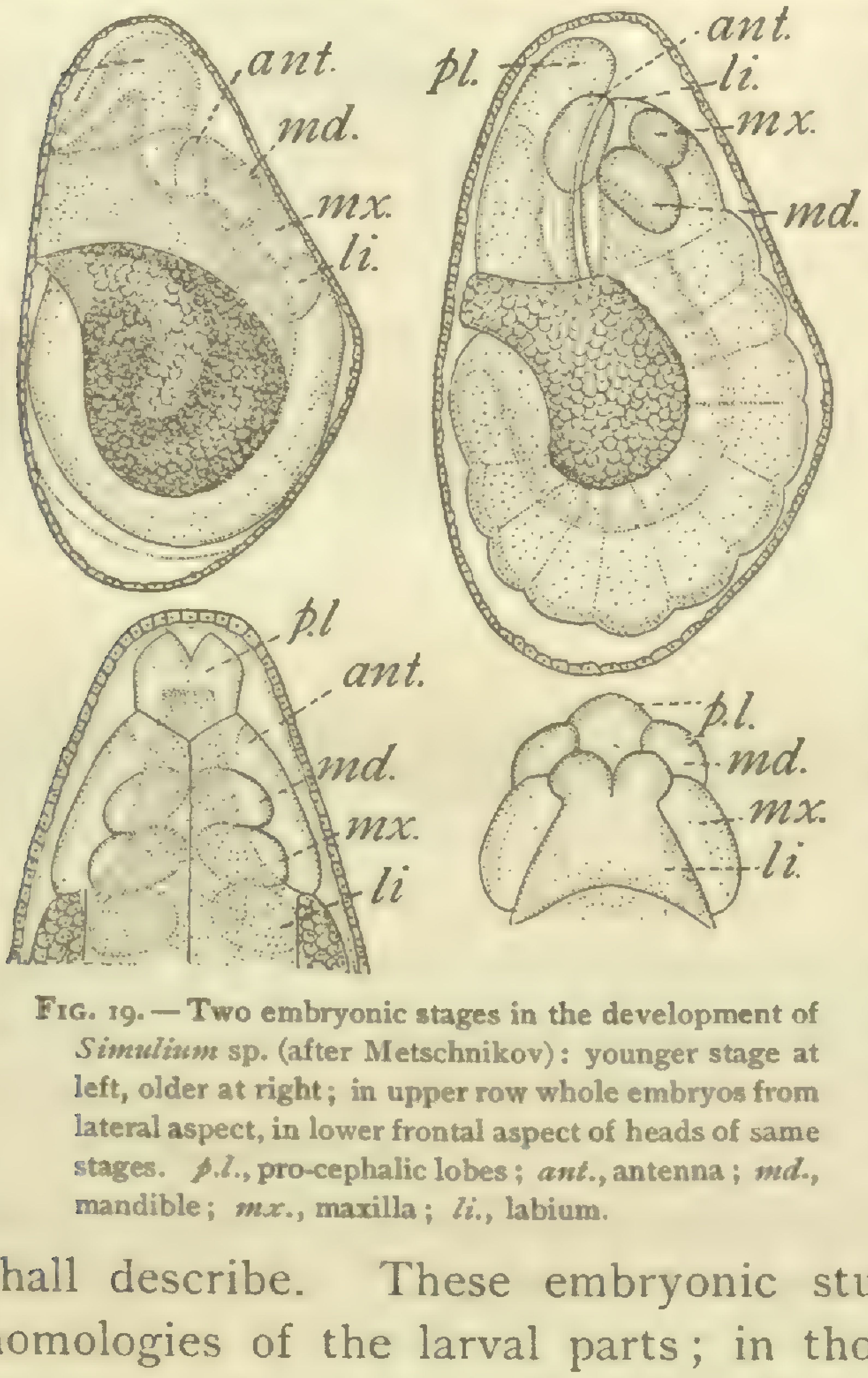

FIG. 19. — Two embryonic stages in the development of *Simulium* sp. (after Metschnikov): younger stage at left, older at right; in upper row whole embryos from lateral aspect, in lower frontal aspect of heads of same stages. *p.l.*, pro-cephalic lobes; *ant.*, antenna; *md.*, mandible; *mx.*, maxilla; *li.*, labium.

As for the embryonic development of the mouth parts, — *i.e.*, the development from budding appendages to definitive larval parts, — that has been done for several Diptera, and in particular by Metschnikov for Simulium, one of the two flies whose postembryonic development I shall describe. These embryonic studies make certain the homologies of the larval parts; in those flies like Simulium, whose larvæ are provided with a biting mouth with full complement of parts, it is easy to note plainly the development of mandibles, maxillæ, and labium from the successive pairs of budding head appendages (Fig. 19), and thus to homologize these parts certainly with the mandibles, maxillæ, and labium of adult insects of incomplete metamorphosis. There remains to determine the relations of the larval mouth parts of Simulium with its very different imaginal mouth parts.

In selecting flies for the study of the postembryonic development of the mouth parts I have chosen two which in the imaginal condition possess all the parts possessed by any fly, and these parts in as generalized condition as is to be found in the order, and which also possess in the larval stage a similarly full complement of mouth parts. Such larvæ as those of the Muscidæ, with their problematical hooks and lack of other parts, and such imagines as the muscid flies, with no parts left except proboscis and maxillary palpi, are impossible for the determination of the relation between larval and imaginal parts. From the mouth parts of the imaginal Simulium and of other nematocerous forms it is not difficult to trace the evolution to the specialized muscid conditions, and if the mouth parts of Simulium and similarly equipped flies can be interpreted, the various members of the dipterous series culminating in the muscids can. So in Simulium and Blepharocera I have found suitable forms for study; both with females possessing the so-called mandibles, both with maxillæ and labium well developed in both sexes, and both with larvæ equipped with biting mouths with unmistakable mandibles, maxillæ, and labia, and in one case, that of Simulium, with the embryonic development of the larval mouth parts fully traced and the homologies certainly[1] determined.

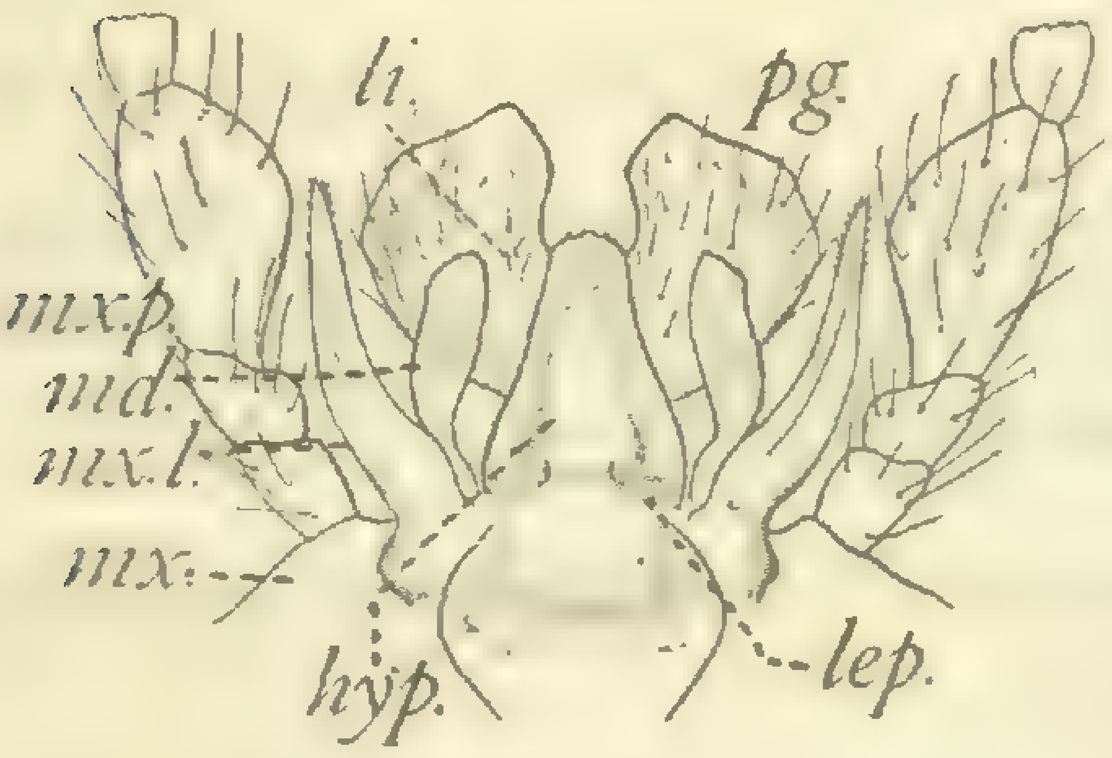

FIG. 20. — Mouth parts of adult *Simulium* sp., female. *l.ep.*, labrum-epipharynx; *hyp.*, hypopharynx; *md.*, mandible; *mx.*, maxilla; *mx.l.*, maxillary lobe; *mx.p.*, maxillary palpus; *li.*, labium; *pg.*, paraglossa.

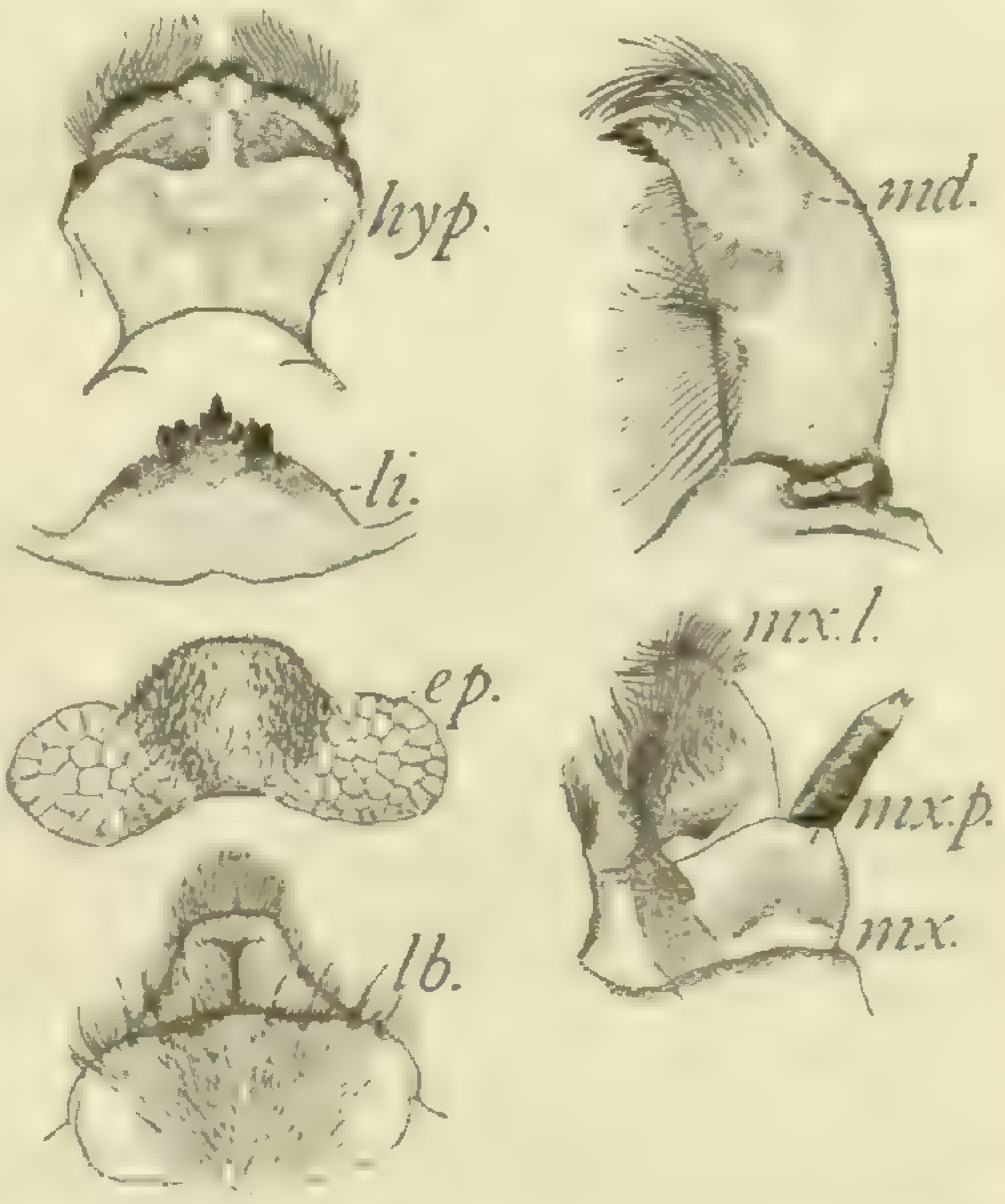

FIG. 21. — Mouth parts of larva of *Simulium* sp. *md.*, mandible; *mx.*, maxilla; *mx.l.*, maxillary lobe; *mx.p.*, maxillary palpus; *lb.*, labrum; *ep.*, epipharynx; *li.*, labium; *hyp.*, hypopharynx.

[1] Metschnikov, E. Embryologische Studien an Insekten, *Zeitschr. f. wiss. Zool.*,

Simulium sp. (Figs. 20–23). — In the female imago[1] the mouth parts (Fig. 20) consist of a short liplike labium (*li.*) composed of a short basal sclerite and three terminal lobes, being the two large paraglossæ (*pg.*) and a median short membranous lobe, the fused glossæ; of a pair of maxillæ (*mx.*), each consisting of a basal sclerite, a long five-segmented palpus (*mx.p.*), and a single pointed, bladelike terminal lobe (*mx.l.*) reaching nearly to the end of the third palpar segment, serrate on its inner margin at the tip and better developed than in most Nematocera; and of a pair of short mandibles (*md.*), broad, thin, and weakly chitinized. As in other nematocerous flies, there is a well-developed labrum-epipharynx (*l.ep.*) and an elongate flattened hypopharynx (*hyp.*). In the males the mandibles are wanting.

In the larva (Fig. 21) the mouth is of the biting type, with short-toothed and heavy mandibles (*md.*), short, jawlike maxilla (*mx.*) with distinct one-segmented palpus (*mx.p.*), and a small, strongly chitinized labium (*li.*) or labial plate. In addition, labrum (*lb.*), epipharynx (*ep.*), and hypopharynx (*hyp.*) are all well developed.

The head of the larva having a thoroughly opaque, strongly chitinized cuticle, it was impossible to clear whole heads sufficiently to make visible the developing imaginal head and its parts, so that the method of sections had to be relied on to reveal the internal conditions. These sections of heads of larvæ of various ages show plainly that the general method of development of the imaginal parts within the larval head, and the correspondence between forming imaginal parts and the corresponding larval parts already noted in the other orders of holometabolous insects, hold good in the Diptera. Fig. 22 shows in sagittal longitudinal section the forming imaginal head parts within the larval head. This section shows particularly well the relation of the forming imaginal antenna to the

vol. xvi, 1866; embryonic development of mouth parts of Simulium described on pp. 392–421.

[1] In describing the adult mouth I shall assign to the various parts those names which, from my earlier study of the comparative anatomy, seem correctly used, and the use of which is confirmed by the results of this ontogenetic study.

larval antenna. In the larva the antennæ are very small compared with their size in the imago, and the imaginal antenna is thus forced, in its development, to occupy a region in the larval head not included in the larval antenna. But the tip of the imaginal organ lies fairly within the larval organ, thus indicating by correspondence in position, what is plainly obvious from anatomical consideration, the homology between the larval and imaginal organs. Similarly the forming imaginal mouth parts are to be found in unmistakable correspondence or homologous relation with the larval parts. By tracing the development of the parts, marked in Fig. 22 as the forming

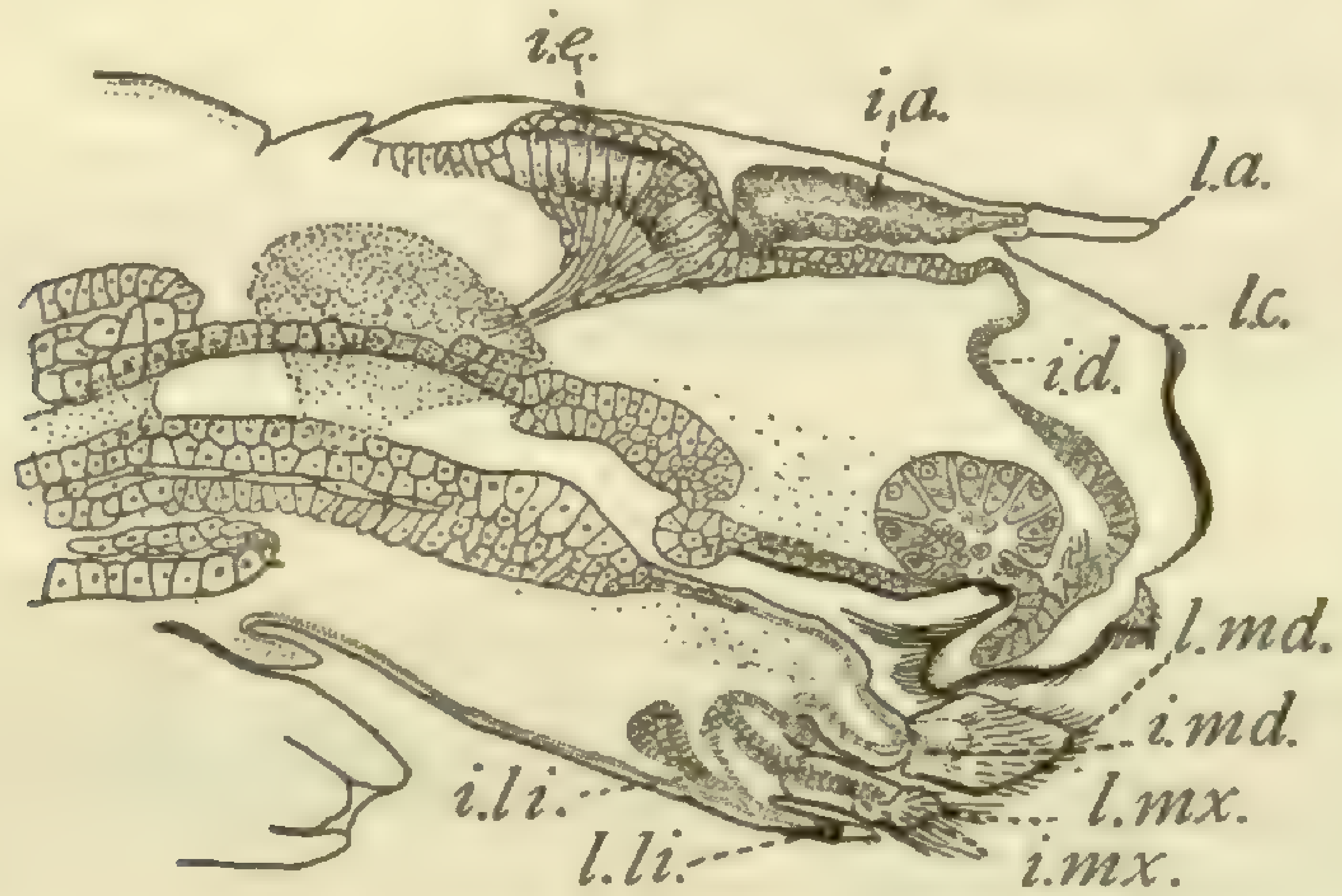

FIG. 22. — Sagittal section through head of old larva of *Simulium* sp., showing forming imaginal head parts within. *l.c.*, larval head wall; *i.d.*, imaginal derm; *l.a.*, larval antenna; *i.a.*, imaginal antenna; *i.e.*, imaginal eye; *l.md.*, larval mandible; *i.md.*, imaginal mandible; *l.mx.*, larval maxilla; *i.mx.*, imaginal maxilla; *l.li.*, larval labium; *i.li.*, imaginal labium.

imaginal mouth parts, through larvæ of successively older ages to pupation and the achievement of the definitive imaginal condition of these parts, it is certain that the parts marked respectively imaginal mandible, imaginal maxillæ, and imaginal labium, lying respectively in the larval mandibles, maxillæ, and labium (with homologies firmly based on ontogenic basis), do develop into those definitive imaginal parts named mandibles, maxillæ, and labium in Fig. 20, illustrating a dissection of the mouth parts in a female adult Simulium. Fig. 23, a horizontal, frontal section through the head of a Simulium larva, shows also the forming imaginal maxilla and mandibles within corresponding larval parts.

Bibiocephala doanei[1] Kellogg (Figs. 24–26). — The Blepharoceridæ, or net-winged midges, agree with the Simulidæ, or black flies, in having the females equipped with mandibles, which in the Blepharoceridæ are well developed as long, slender, bladelike saws (see Fig. 24, *md.*) used to lacerate the bodies (as I have observed) of the tiny midges caught as prey by the bloodthirsty females. In addition the adult females have maxillæ (Fig. 24, *mx.*) with well-developed lobe (*mx.l.*) and long five-segmented palpus (*mx.p.*), and a labium (*li.*) consisting of strong elongate basal sclerite which presents indications of a line of fusion of submentum and mentum, and a pair of free fleshy terminal lobes, the paraglossæ (*pg.*). The males are equipped like the females except for the mandibles.

The larva of *Bibiocephala doanei* has a biting mouth (Fig. 25) composed of short, stout, crushing mandibles (*md.*), weaker jawlike maxillæ (*mx.*) without palpi, and a soft liplike labium (*li.*). In addition there are well-developed labrum-epipharynx (*l.ep.*) and hypopharynx (*hyp.*).

The development of the imaginal head shows the same phenomena as in Simulium. In Fig. 26, from a vertical transverse section through the head of an old larva, the derm of the forming imaginal head is plainly seen in continuous layer, modified at *i.e.* to produce the developing compound eyes and at *mx.* and *md.* the forming imaginal mandibles and maxillæ. In this section the imaginal parts of the maxillæ visible are the forming palpi, and their definitive, long, segmented condition is plainly to be seen in these telescoped organs tucked tightly inside the larval maxillæ. The forming mandibles do not yet show their definitive character, but in tracing these organs through a series of older larvæ the gradual taking-on of the slender sawlike character is manifest. The series of Blepharocera preparations which I have show even more plainly than the Simulium preparations the perfect correspondence and "box-in-box" sort of relation which exists between the larval

[1] This blepharocerid fly was described by me in *Psyche*, vol. ix (April, 1900), pp. 39–41, 2 figs., under the name *Liponeura doanei*. In a recent revision of the North American Blepharoceridæ, now in press, I refer this species to the genus Bibiocephala.

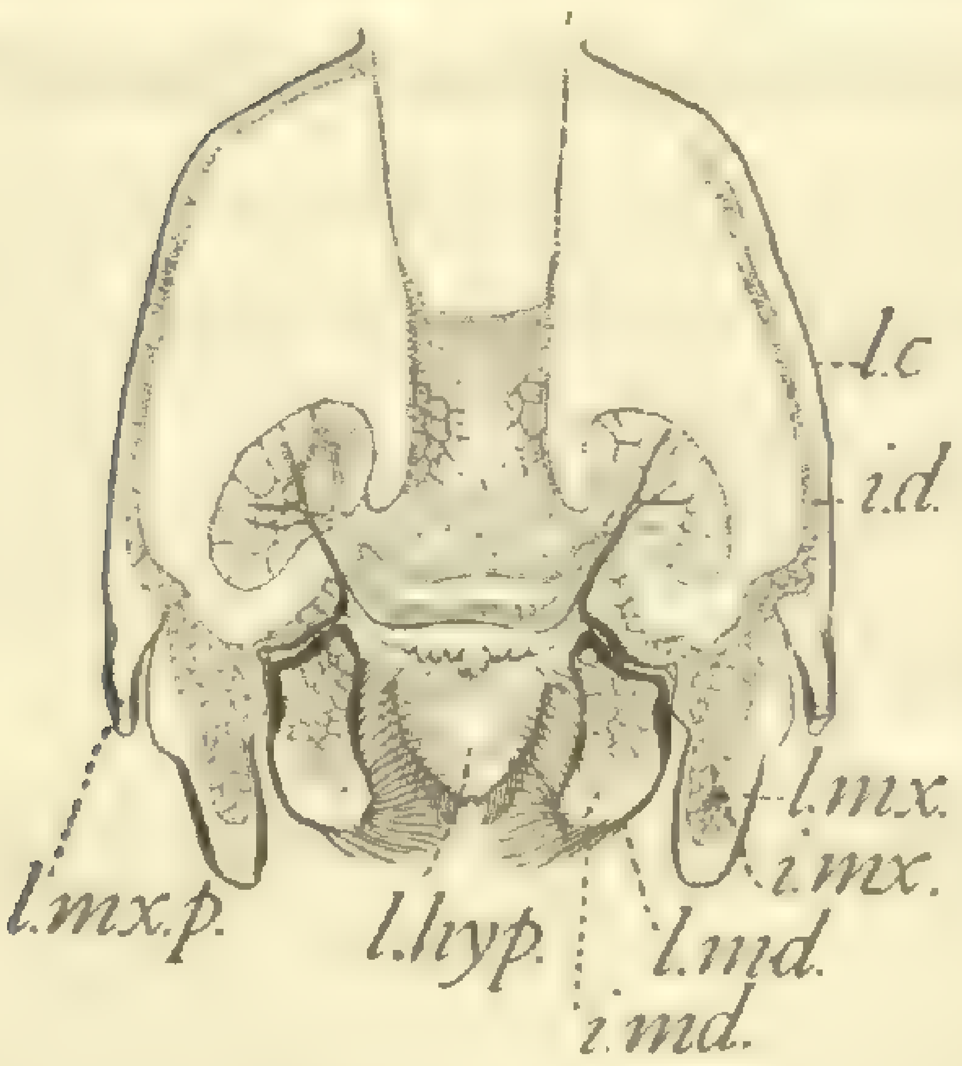

FIG. 23.

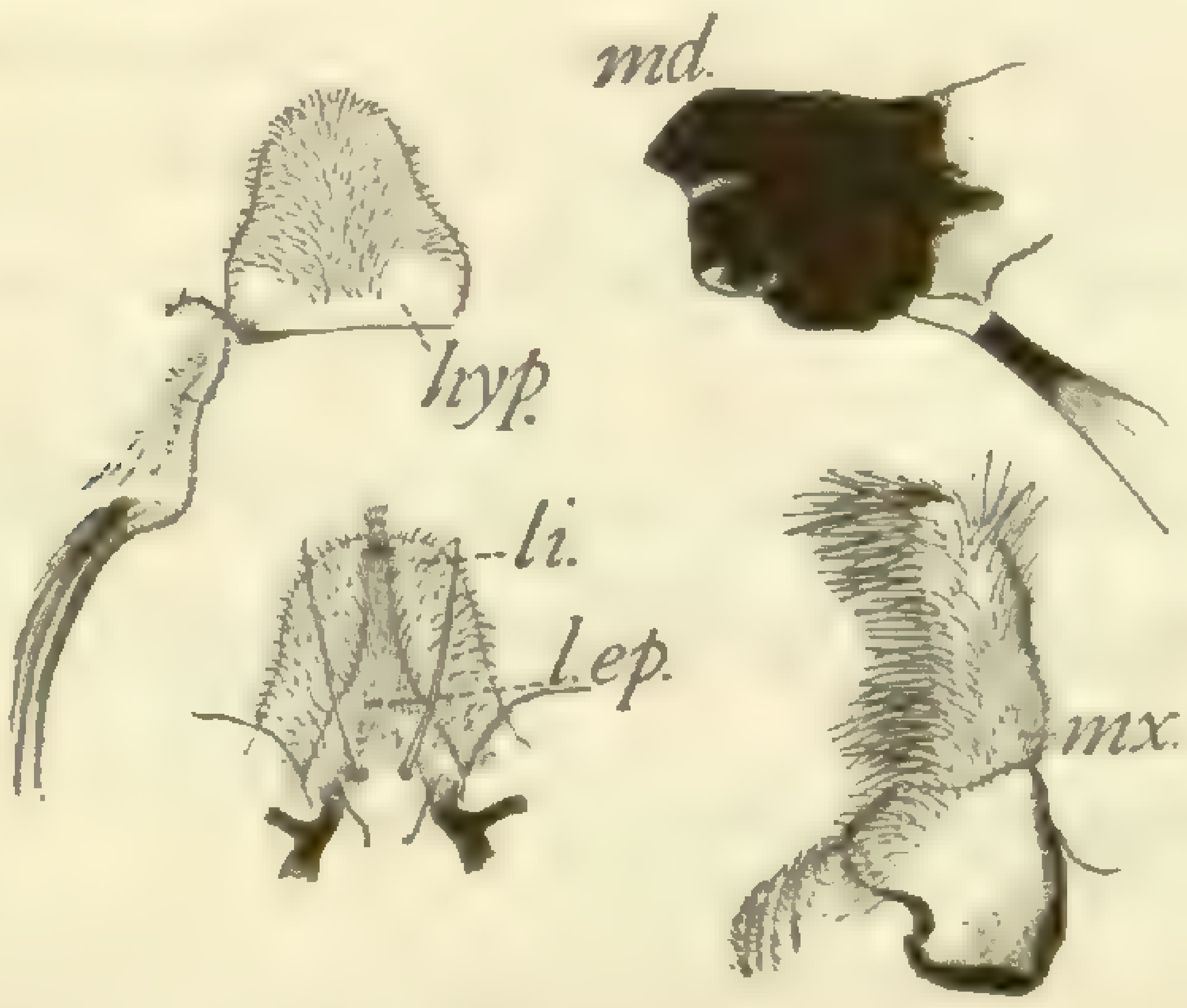

FIG. 25.

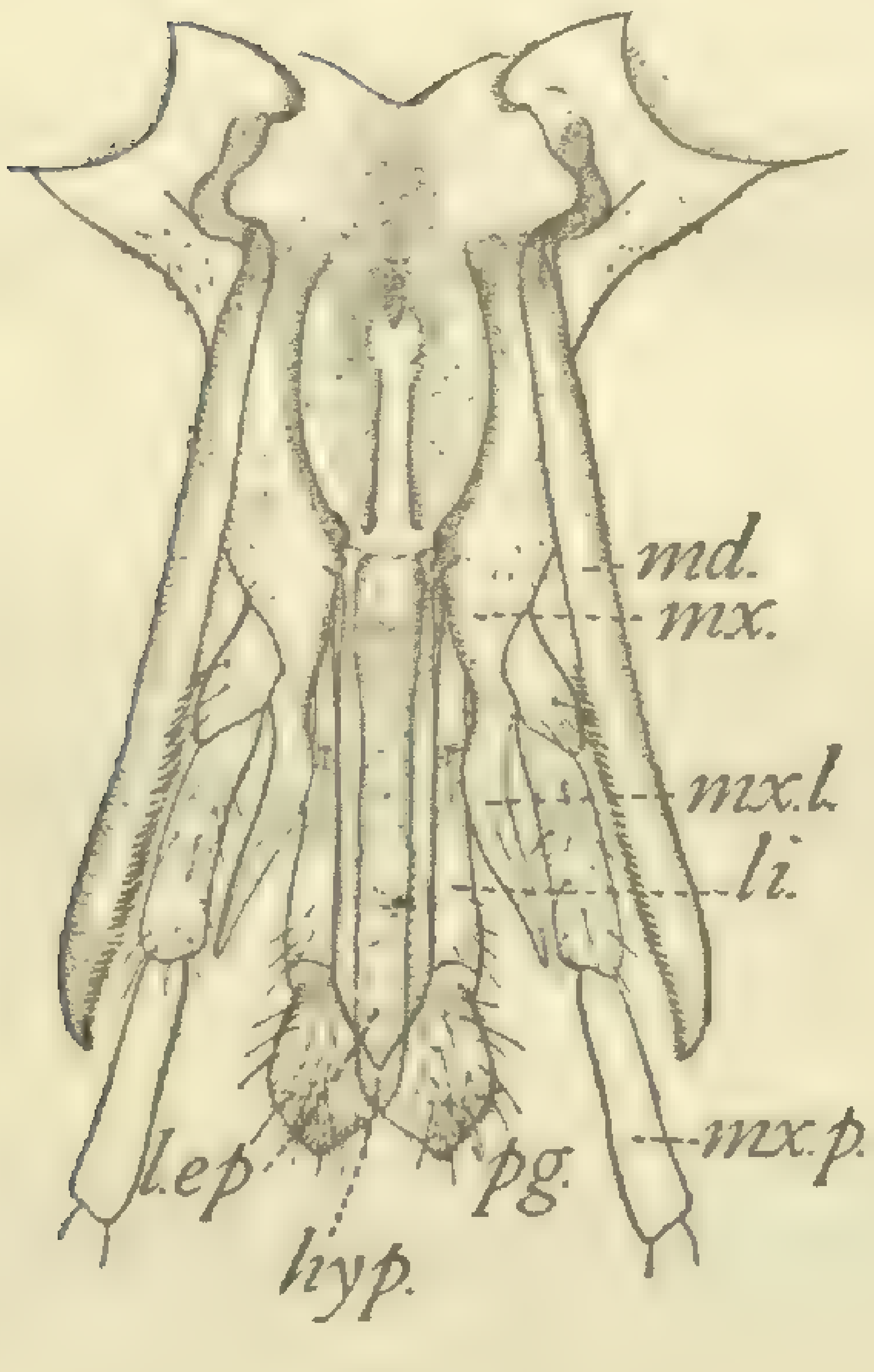

FIG. 24.

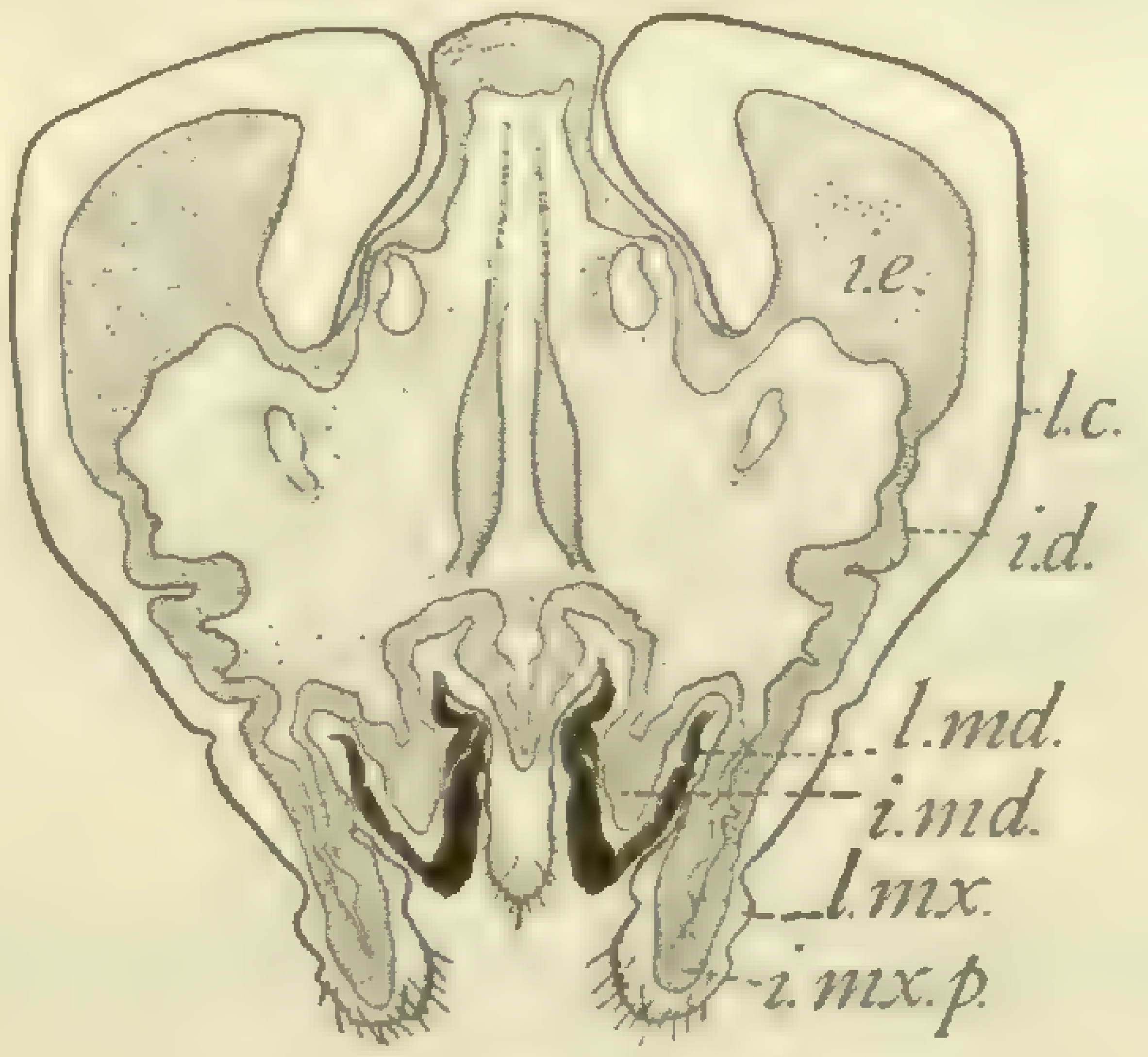

FIG. 26.

FIG. 23. — Frontal section, through the head of old larva of *Simulium* sp., showing forming imaginal parts. *l.c.*, larval cuticle; *i.d.*, imaginal derm; *l.md.*, larval mandible; *i.md.*, imaginal mandible; *l.mx.*, larval maxilla; *i.mx.*, imaginal maxilla; *l.mx.p.*, larval maxillary palpus; *l.hyp.*, larval hypopharynx.

FIG. 24. — Mouth parts of adult *Bibiocephala doanei*, female; *md.*, mandible; *mx.*, maxilla; *mx.l.*, maxillary lobe; *mx.p.*, maxillary palpus; *li.*, labium; *pg.*, paraglossa; *l.ep.*, labrum-epipharynx; *hyp.*, hypopharynx.

FIG. 25. — Mouth parts of larva of *Bibiocephala doanei*. *md.*, mandible; *mx.*, maxilla; *li.*, labium; *l.ep.*, labrum-epipharynx; *hyp.*, hypopharynx.

FIG. 26. — Frontal section, through head of old larva of *Bibiocephala doanei*, showing forming imaginal head parts within. *l.c.*, larval head wall; *i.d.*, imaginal derm; *i.e.*, imaginal eye; *l.md.*, larval mandible; *i.md.*, imaginal mandible; *l.mx.*, larval maxilla; *i.mx.p.*, imaginal maxillary palpus.

mouth parts, of whose homologies no doubt can exist, and the forming imaginal parts, of whose homologies, in definitive condition, I thought myself long ago able to speak confidently on a basis of comparative anatomical study, but of which now on a basis of ontogenetic study I am simply without doubt.

Stanford University, California.
January, 1902.

AN ANALYTICAL KEY TO THE GENERA OF THE FAMILY FORMICIDÆ, FOR THE IDENTIFICATION OF THE WORKERS.

CARLO EMERY.

(Translated by William Morton Wheeler.[1])

Since the publication by Mayr, in 1865, of the volume on the Formicidæ of the voyage of the *Novara*, no comprehensive work has appeared which could be of service in the identification of the genera of this family. The number of these genera has increased considerably in the mean time, and the definitions formerly given by Mayr for a number of them are no longer exact, as their characters have been modified by the discovery of new species. Moreover, certain genera have been subdivided, others fused together; and all of this is to be found scattered about in a host of detached publications, so that it is almost impossible for any one who is not a consummate specialist to find his way about in the labyrinth.

I originally began, for my own personal use, to construct analytical tables for the workers of the subfamilies Myrmicinæ and Ponerinæ; but I now believe that I would render a service to entomologists by publishing these tables, after having revised and completed them. I have added tables of the genera of the other subfamilies, together with a table of the characters of the subfamilies themselves, likewise in analytical form.

[1] For the present authorized translation Professor Emery has carefully revised the tables of the Myrmicinæ, Dolichoderinæ, and Camponotinæ, of his "Clef Analytique des Genres de la Famille des Formicides, pour la Determination des neutres" (*Ann. Soc. Entomol. Belgique*, tome xl (1896), pp. 172–189), and has, moreover, permitted me to translate the as yet unpublished German table for the Dorylinæ and Ponerinæ which he has been preparing for *Das Thierreich*. The work has thus been brought up to date and cannot fail to be of great service to myrmecologists the world over. — W. M. Wheeler.

I trust that these tables will facilitate the labor of identification and enable those who are beginning to study the exotic ants to find their way more easily. I am well aware of the fact that one may find one's self in doubt at certain bifurcations of the path. How is one to know, *e.g.*, whether the worker is dimorphic, when one has only a single specimen of the species? I have made no use of such characters except when I had nothing better to present, and then I have tried to reinforce them as much as possible with accessory characters. Sometimes I have cited characters peculiar to the males and females, as these are often the most important in distinguishing certain genera, the workers of which present only feeble or insignificant differences. Nevertheless, I decline to attempt for the present an analysis of the sexual forms, which are still too imperfectly known.

In the enumeration of the segments of the abdomen I include the one or two constituting the pedicel, so that the segment following this, and usually designated by other authors as the first abdominal, is for me the third in the Myrmicinæ, the second in the Camponotinæ, etc.; the last visible segment is, therefore, always the sixth in the females and workers, the seventh in the males. In the male I designate as "subgenital lamina" what is usually, but improperly, called the hypopygium and is in reality the ventral lamina of the eighth segment. For the anatomy of the gizzard and the poison apparatus I would refer the reader to the works of Forel, Dewitz, and myself.[1]

Having adopted the dichotomic form for the identification of the genera, it follows that the order cannot express their natural affinities; but this can lead to no inconvenience in a

[1] Forel, A. Études myrmécologiques en 1878. Anatomie du Gésier des Fourmis, *Bull. Soc. Vaudoise Sc. Nat.*, vol. xv (1878), pp. 339–362, Pl. XXIII; Der Giftapparat und die Analdruesen der Ameisen, *Zeitschr. f. wiss. Zool.*, Bd. xxx. Suppl. (1878), pp. 28–68, Taf. III–IV.

Dewitz, H. Ueber Bau und Entwickelung des Stachels der Ameisen, *Zeitschr. f. wiss. Zool.*, Bd. xxviii (1877), pp. 527–556, Taf. XXVI.

Emery, C. Ueber den sogenannten Kaumagen einiger Ameisen, *Zeitschr. f. wiss. Zool.*, Bd. xlvi (1888), pp. 378–412, Taf. XXVII–XXIX.

In the plates will be found figures of all the forms of the gizzard in the Dolichoderinæ.

work the aim of which is essentially practical. I have marked with an asterisk the names of the genera represented in the Palearctic fauna.[1]

Characters of the Subfamilies.

I. Cloacal orifice in the shape of a slit; sting well developed or rudimental.

§ Sting developed, though sometimes very small, but capable nevertheless of being exserted from the abdomen. The first two segments of the abdomen usually modified, either forming together a two-jointed pedicel, or the first alone (petiole) forming the pedicel, the second (postpetiole) being merely constricted posteriorly and articulating with a spheroidal surface of the third segment, which is usually transversely striated (stridulatory organ); rarely the second segment is not appreciably modified.

† Nymphs usually enveloped in a cocoon; pedicel consisting of a single segment, more rarely of two, but in this case the frontal carinæ are very close to each other and do not cover the insertions of the antennæ (Dorylinæ) or the mandibles are linear and denticulate (Myrmecia).

a. Frontal carinæ very close to each other, almost vertical, not at all covering the antennal insertions (except Acanthostichus); abdominal pedicel of one or two segments. In the male the genitalia are completely retractile and the subgenital lamina is usually (perhaps always) furcate; cerci absent

1st subfamily, Dorylinæ

b. Frontal carinæ separated or close together; in the latter case they are dilated anteriorly to form an oblique or horizontal lamina, covering in part the insertion of the antennæ; abdominal pedicel of a single segment (except Myrmecia); copulatory organs of the male incompletely retractile; subgenital lamina never furcate (except in Paraponera); cerci nearly always present . . 2d subfamily, Ponerinæ

†† Nymphs naked; pedicel of two segments; rarely the postpetiole is attached to the following segment over its whole extent. Frontal carinæ usually separated from each other. In the male the copulatory organs are almost always exserted (being entirely retractile only in certain genera of the group Solenopsidii); cerci nearly always present (except Anergates)

3d subfamily, Myrmicinæ

[1] In addition, I have indicated by heavy type, in the translation, the names of all genera known to be represented in the ant fauna of the United States.— W. M. Wheeler.

§§ Sting rudimentary (except Aneuretus); abdominal pedicel consisting of a single segment; no constriction between the second and third segments of the abdomen; the poison glands are often rudimental and there are anal glands which secrete an aromatic product of characteristic odor (Tapinoma-odor). Nymphs without a cocoon
4th subfamily, DOLICHODERINÆ

II. Cloacal orifice round, terminal, surrounded by a fringe of hairs; sting transformed into a sustentacular apparatus for the orifice of the poison vesicle, which has a peculiar structure — called by Forel "pulviniferous vesicle" (*vessie à coussinet*). Abdominal pedicel consisting of a single segment; no constriction between the second and third segments. Nymphs rarely naked, most frequently enclosed in a cocoon. Male genitalia not retractile
5th subfamily, CAMPONOTINÆ

1st and 2d Subfamilies: DORYLINÆ *and* PONERINÆ.

1. Eyes large, three ocelli, mandibles slender, denticulate; postpetiole campanulate, narrower than the succeeding segment (Australian)
Myrmecia Fab.
Of a different conformation 2
2. Antennæ 6-jointed; first joint of hind tarsi dilated (African)
Melissotarsus Emery
Antennæ with more than six joints; tarsi simple 3
3. Postpetiole hardly wider than the petiole, and much narrower than the anterior border of the following segment, and on this account appearing as the second segment of the abdomen 4
Postpetiole of a different conformation 6
4. Antennæ 12-jointed (neotropical) . . . . **Eciton** Latr.
Antennæ 9–10-jointed 5
5. Hind legs without spurs, funiculus not club-shaped (Asia, Africa, Australia) . . . . Ænictus Shuckard
Hind legs with spurs; last antennal joint separated off as a club (Asia, Australia) . . . . Cerapachys F. Smith
(Subgenera Oöceræa and Cysias)
6. Postpetiole shorter than the following segment and somewhat narrower, but not distinctly separated from the latter; mesoëpinotal suture obsolete, promesonotal suture distinct; pygidium 3-pointed; antennæ 7–12-jointed; no eyes (Asia, Africa) . . . . . Dorylus Fabr.
Postpetiole as in the preceding; mesoëpinotal suture distinct, promesonotal suture obsolete; antennæ 12-jointed (neotropical)
Cheliomyrmex Mayr
Of a different conformation 7
7. The frontal carinæ, which are fused with each other and with the clypeus, form a plate projecting out over the mandibles; the antennæ are inserted close to the anterior margin of this structure . . . 8

Frontal carinæ of a different conformation 9

8. Antennæ 12-jointed; abdomen stretched out straight (Africa) Probolomyrmex Mayr

Antennæ 9-jointed, tip of the abdomen deflected down and forward (America, Africa, Australia) . . . . . . Discothyrea Roger

9. Frontal carinæ very close to each other; antennæ inserted very near the oral margin. Tip of abdomen strongly deflected downward 10

Frontal carinæ of a different conformation, or the tip of the abdomen not deflected 11

10. Clypeus in front projecting in the middle; petiole nodiform (America, Europe, Australia) . . . . *** Sysphincta** Roger

Clypeus not projecting in front; petiole scale-like (America, Europe) *** Proceratium** Roger

11. Abdomen straight and constricted behind each segment; pygidium impressed or furcate (South America, Australia) Sphynctomyrmex Mayr

Abdominal segments not constricted 12

12. Body cylindrical with an elongated head, usually with one ocellus on the vertex 13

Of a different conformation 14

13. Antennæ 12-jointed (neotropical) . . . . Cylindromyrmex Mayr

Antennæ 11-jointed (Africa) . . . . Simopone Forel

14. Petiole inserted behind on the postpetiole throughout its whole breadth; antennæ 12-jointed 15

Petiole constricted off from the postpetiole, and separate . . . 21

15. Middle and hind tibiæ without spurs, claws very large, eye well developed (Australia) . . . . Onichomyrmex Emery

Middle and hind tibiæ spurred; eye very small 16

16. Pygidium with a row of prickles on its lateral border; petiole square; antennæ robust (South America) . . . . . Acanthostichus Mayr

Pygidium without prickles on its border 17

17. Very small (at most 2½ mm.); funiculus with a 4-jointed club, only one spur well developed on the middle and hind legs (South America, Australia) . . . . Prionopelta Mayr

Larger, middle and hind tibiæ each with two spurs 18

18. Integument shining 19

Integument at least in part opaque, densely sculptured 20

19. Antennæ very thick, the whole funiculus club-like (Asia, Australia) Myopopone Roger

Antennæ with filiform funiculus, but slightly thickened towards its tip. (Australia) . . . . Amblyopone Erichson

20. Mandible blunt at its tip or with a spatulate dilatation (Madagascar, India) . . . . Mystrium Roger

Mandible pointed at its tip (America, Europe, Asia, Australia) *** Stigmatomma** Roger

21. Mandibles inserted on the anterior corners of the head 22
Mandibles inserted in the middle of the anterior border of the head 55
22. Frontal carinæ approximated and almost perpendicular, not covering the insertions of the antennæ. Postpetiole strongly constricted off from the following segment 23
Frontal carinæ more or less dilated, and covering the insertions of the antennæ at least in part; antennæ always 12-jointed 26
23. Petiole sharply margined laterally; last joint of antenna not particularly large (Asia, Australia, Africa) . . . . . Phyracaces Emery
Petiole not margined laterally 24
24. Last antennal joint much longer than the penultimate joint, forming a one-jointed club (Asia, Australia, Africa) . Cerapachys F. Smith
The last two or three joints of the antenna form an indistinctly separated club (India) . . . . Lioponera Mayr
25. Frontal carinæ farther from each other than from the sides of the head. Mandibles with very long thorn-like teeth (South America)
Thaumatomyrmex Mayr
Frontal carinæ nearer to each other than to the sides of the head; mandibles of a different conformation 26
26. Mandibles slender, when closed first strongly converging, then directed straight forward, beak-like, below with a powerful tooth, eye very large, placed anteriorly (India) . . . . . Harpegnathus Jerdon
Mandibles of a different conformation 27
27. Middle legs with two simple spurs; hind legs with a simple and a pectinate spur (America, Africa, Asia) . . . Centromyrmex Mayr
Spurs of the middle and hind legs of like structure 28
28. Claws pectiniform 29
Claws not pectiniform 30
29. Mandibles slender with a few large teeth along the medial border (Australia) . . . . Prionogenys Emery
Mandibles slender and toothless, or broader with dentate edges (warm regions of the whole world) . . . . **Leptogenys** Roger
30. Antennal fovea continued back into a groove which bends around the eye and is capable of enclosing the antennal scape and a portion of the funiculus (South America) . . . . . Paraponera F. Smith
Of a different conformation 31
31. Margin of clypeus denticulate; pronotum on either side with a tooth-like projection (India) . . . . Odontoponera Mayr
Clypeus not denticulate 32
32. Frontal carinæ not broadened into lobes anteriorly, but only slightly dilated, widely separated from each other; middle and hind legs with well-developed median spur; lateral spur, when present, very small 33
Frontal carinæ converging posteriorly and there usually closely approximated. Anteriorly they are dilated to form a horizontal lobe . 39
33. Antennæ with 3-jointed club; claws simple 34

Antennæ without a differentiated club; claws usually toothed or split 35

34. Petiole distinctly pedunculate; thorax above with distinct sutures (South America) . . . . Typhlomyrmex Mayr

Petiole not pedunculate; thorax above without sutures (New Guinea) Rhopalopone Emery

35. Third abdominal segment strongly fornicate dorsally, so that its posterior margin is directed downward, or even somewhat forward; thoracic dorsum without sutures 36

Of a different conformation 37

36. Eye small; third abdominal segment strongly deflected (South America) Alfaria Emery

Eyes larger; third abdominal segment but slightly deflected (southern Asia) . . . . Stictoponera Mayr

37. Promesonotal suture obsolete, or distinct as a deep depression, which does not, however, interrupt the sculpture of the integument (South America) . . . . Ectatomma F. Smith

Promesonotal suture distinct and sharply cutting through the sculpture of the integument 38

38. Antennal fovea elongated backwards as a groove; epinotum with teeth or spines; hind coxa unarmed (South America, Australia) Acanthoponera Mayr

Antennal fovea not elongated posteriorly; epinotum unarmed; hind coxa unarmed (Australia) . . . . Rhytidoponera Mayr

Antennal fovea not elongated: epinotum unarmed; hind coxa with a spine (South America) . . . . Holcoponera Mayr

39. Episternum of mesothorax hollowed out; petiole behind with two teeth or spine (India and Australia) . . . . Diacamma Mayr

Episternum of mesothorax not hollowed out 40

40. Medial spur of the middle and hind legs alone developed, the lateral spur is lacking, or very small (Trapeziopelta) 41

Both spurs of the middle and hind legs well developed 47

41. Integument smooth or sculptured, without pubescence 42

Integument delicately sculptured; at least the abdomen pubescent 45

42. Clypeus in the middle with a slender projecting lobe; lateral spur small but distinct (Malasia and Papuasia) . . . . Trapeziopelta Mayr

Clypeus without a lobe 43

43. Mandible sickle-shaped, flat and pointed (Africa) Psalidomyrmex André

Mandible slender, with a few teeth on the medial border . . . 44

44. Mandible obtuse at the end (Africa) . . . Plectroctena F. Smith

Mandible pointed, its medial border with two teeth (Ceylon) Myopias Roger

45. Clypeus in front with a needle-shaped process (South America) Belonopelta Mayr

Clypeus without a point in front 46

46. Antenna with a 4-jointed club (Asia and Papuasia) Cryptopone Em.
Antenna without a club, or with an indistinctly marked off 5-jointed club (warm and temperate regions of the whole world) * **Ponera** Latr.
47. Clypeus flat, separated from the frontal carinæ by a scarcely perceptible suture or not at all; body opaque, with fine gray pubescence (warm regions of the whole world) . . . . . Platythyrea Mayr
Clypeus separated off by a distinct suture 48
48. Anterior border of clypeus with two teeth 49
Clypeus not bidentate 50
49. Epinotum with two teeth; petiole pointed above (Africa) Streblognathus Mayr
Epinotum unarmed; petiole not pointed (South America) Dinoponera Roger
50. Clypeus in the middle with a raised piece margined on either side (Africa) . . . . Paltothyreus Mayr
Clypeus arched or carinate 51
51. Cheek in front of the eye with a longitudinal carina 52
Cheek without a carina 53
52. Claws dentate (Africa) . . . . Megaponera Mayr
Claws simple (South America) . . . . Neoponera Emery
53. Eye in the middle or behind the middle of the side of the head (Africa) . . . . Ophthalmopone Forel
Eye in front of the middle of the side of the head 54
54. Mesoëpinotal suture obsolete or not impressed; mesonotum not arched in profile (warm regions of the whole world) **Pachycondyla** F. Smith
Mesoëpinotal suture impressed; mesonotum distinctly arched in profile . . . . Euponera Forel
55. Antennal foveæ confluent with each other behind the frontal carinæ; petiole prolonged above into a thorn-like point (warm regions of the globe) . . . . **Odontomachus** Fabricius
Antennal foveæ not confluent behind 56
56. Antennal fovea bordered by a carina laterally behind the eye; head not emarginate posteriorly; petiole pointed (Madagascar) Champsomyrmex Emery
Antennal fovea without a lateral keel behind the eye; head always emarginate posteriorly; petiole usually not pointed * Anochetus Mayr

3d Subfamily: MYRMICINÆ.

1. Clypeus not prolonged back between the frontal carinæ,[1] which are closely approximated to each other; antennæ 12-jointed (tribe Pseudomyrmii) 2

[1] In some species of Pseudomyrma the clypeus seems to be continued back narrowly between the frontal carinæ, but this prolongation is the equivalent of the frontal area; it is often distinct from the clypeus.

Clypeus almost always prolonged between the frontal carinæ, which are more or less separated; in the opposite case, the antennæ are 11-jointed 3

2. Clypeus suddenly descending in front, or as if inflected or subtruncated, usually armed with teeth at the level of this inflection; rarely it is uniformly sloping and deeply emarginate at the anterior border (Africa, Asia, Oceanica) . . . . Sima Roger

Clypeus neither inflected nor dentate, not or only feebly emarginate (America) . . . . **Pseudomyrma** Guerin

3. Antennæ 7-jointed, without a distinct club (13-jointed in the male); frontal carinæ, as usual, distant from the lateral borders of the head; thorax spinose (tribe Myrmicarii) . . . . Myrmicaria Saunders

Antennæ of a different conformation (when 7-jointed, the last joint is enlarged or forms part of a differentiated club, or the scape may be enclosed in a deep groove, or the thorax is without spines) . . 4

4. Antennal fovea or groove placed at the side of the head: the carina formed by its dorsal margin (and which does not correspond to the frontal carina of other ants) passes outside of the eye; posterior angles of the head pointed or prolonged or denticulate; antennæ 11-jointed in all the sexes (tribe Cataulacii) . Cataulacus F. Smith

Of a different conformation 5

5. The antennal fossæ terminate behind on the sides of the head, pass above the eye and are sufficiently deep to conceal the whole antennal scape; antennæ 11-jointed, without differentiated club: gizzard fungiform, of peculiar structure (tribe Cryptocerii) (America) . . . 6

Antennal fossæ differently placed, or the antennæ of a different conformation; gizzard of the usual form 7

6. Antennal foveæ approximated in front, diverging strongly behind, not reaching the sides of the head except at their extremities
Procryptocerus Emery

Antennal foveæ covered throughout their length by the lateral border of the head . . . . **Cryptocerus** Fabricius

7. Postpetiole articulated to the dorsal surface of the following segment (tribe Crematogastrii) . . . . ***Crematogaster** Lund

Postpetiole inserted at the anterior end of the following segment . 8

8. Head cordiform, emarginate behind, with the posterior angles strongly rounded and devoid of spines; last joint of antennæ very much smaller than the preceding joint (tribe Dacetii) 9

Head of a different conformation 15

9. Antennal foveæ short; antennæ 11-jointed 10

Antennal foveæ as long as the scape 11

10. Only the last joint of the antennæ longer than the preceding joint
Daceton Perty

Last two joints of the antennæ longer than the preceding
Acanthognathus Mayr

11. Antennal foveæ shallow, at the medial side of the eye; antennæ 5-jointed, the third much elongated . . . Orectognathus F. Smith
Of a different conformation 12
12. Antennal foveæ placed at the dorsal or medial side of the eyes . 13
Antennal foveæ placed at the lateral side of the eyes 14
13. Antennæ 6-jointed . . . . * **Strumigenys** F. Smith
Antennæ 4-jointed . . . . * Epitritus Emery
14. Antennæ 6-jointed . . . . Epopostruma Forel
Antennæ 7–8-jointed . . . . Rhopalothrix Mayr
Antennæ 12-jointed . . . . Ceratobasis F. Smith
15. Antennæ 11-jointed, without distinct club, or a club consisting of a single joint (tribe Attii, America) 16
Club of several joints, or the antennæ not 11-jointed 20
16. Frontal carinæ very close to each other and dilated at the anterior extremity; clypeus not distinctly prolonged between them . . 17
Frontal carinæ separated, embracing the posterior extremity of the clypeus 18
17. Integument opaque and even, bristling with long, fine hairs
Apterostigma Mayr
Integument bristling with tubercles and spines, with hooked and scale-like hairs . . . . Myrmicocrypta F. Smith
18. No erect hairs on the body; antennal foveæ usually prolonged to the posterior corners of the head . . . . . . **Cyphomyrmex** Mayr
Body bearing erect hairs 19
19. Integument even, bearing only delicate oblique hairs
Sericomyrmex Mayr
Integument rough, bearing stiff or hooked hairs . . **Atta** Fabricius
20. The shallow antennal foveæ bordered laterally by an abrupt carina; antennæ 11-jointed, with a club of three joints, the last of which is decidedly predominant 21
Of a different conformation 22
21. Clypeus transversely arched, almost straight in a longitudinal direction
Ochetomyrmex Mayr
Clypeus arched both longitudinally and transversely Wasmannia Forel
22. Club of the antennæ 2-jointed, the last joint much larger than the other (tribe Solenopsidii and the genus Phacota) 23
Antennal club of a different conformation or indistinct 28
23. Antennæ 9-jointed (10-jointed in the female and 13-jointed in the male)[1]; no dimorphism among the workers . Carebara Westwood
Antennæ 12-jointed . . . . Adelomyrmex Emery
Antennæ 10- or 11-jointed 24

[1] Professor Forel refers to the genus Oligomyrmex Mayr, the worker of which is unknown, an undescribed Australian species with strongly dimorphic workers. The antennæ are 9-jointed, as in Carebara worker and in Oligomyrmex female.

24. Antennæ 10-jointed 25
Antennæ 11-jointed 26
25. Dimorphism of the workers usually but slightly marked, or, in the opposite case, the head of the worker major is subquadrate or broader than long (antennæ 10- to 11-jointed in the female)
* **Solenopsis** Westwood
Dimorphism of the workers very marked; head of the worker major elongated (antennæ 11-jointed in the female) . Aëromyrma Forel
26. Thoracic sutures indistinct . . . . * Phacota Roger
Mesoëpinotal suture strongly marked 27
27. Ninth antennal joint conspicuously longer than the eighth, though much shorter and especially narrower than the tenth
Diplomorium Mayr
Ninth joint of the antennæ not distinctly longer than the eighth; workers polymorphic; soldiers with enormous heads
Pheidologeton F. Smith
28. Antennal foveæ deep, capable of containing the whole scape, and placed along the sides of the head 29
Antennal foveæ less deep or differently placed 30
29. Antennæ 9-jointed (10-jointed in the male as in Tetramorium); mesonotum with a blade-like posterior edge and usually armed with spines
Meranoplus F. Smith
Antennæ 11-jointed, the last joint very large . Calyptomyrmex Emery
30. Erect hairs on the body trifid . . . . . . * Triglyphothrix Forel
Hairs not trifid 31
31. Posterior border of the clypeus raised in the form of a trenchant ridge which borders the antennal foveæ in front 32
Posterior border of the clypeus not forming a ridge 38
32. Mandibles pointed, without apical border . * Strongylognathus Mayr
Mandibles with dentate apical border 33
33. Portion of the clypeus in front of the antennal insertion narrow, but not reduced to a mere ridge (antennæ of the male 10-jointed) (forming with the four preceding genera the tribe Tetramorii) . . . 34
Portion of the clypeus in front of the antennal insertion reduced to a trenchant ridge (antennæ of male 13-jointed) 37
34. Antennæ 12-jointed 35
Antennæ 11-jointed 36
35. Epinotum armed with spines or teeth . . . . * **Tetramorium** Mayr
Epinotum rounded, unarmed . . . . Rhophomyrmex Mayr
36. Thoracic dorsum deeply impressed at the mesoëpinotal suture
Dacryon Forel
Thoracic dorsum scarcely or not at all impressed at the mesoëpinotal suture . . . . **Xiphomyrmex** Forel
37. Antennæ 11-jointed . . . . Pristomyrmex Mayr
Antennæ 12-jointed 38

38. Petiole pedunculate in front; dimorphism of the workers very marked Acanthomyrmex Emery
Petiole not pedunculate in front; no appreciable dimorphism in the workers . . . . * **Myrmecina** Curtis
39. Antennæ 7–10-jointed, the last joint very large; thorax without spines or teeth; eyes present . . . . Allomerus Mayr
Antennæ 10–12-jointed; when there are ten, the eyes are wanting or the epinotum is armed with two spines 40
40. Without eyes 41
With eyes, sometimes small, but quite distinct 43
41. Antennæ 12-jointed, without distinct club; insects very small * Leptanilla Emery
Antennæ 10–11-jointed, with 3-jointed club 42
42. Postpetiole armed with a spine on its lower surface Liomyrmex Mayr
Postpetiole unarmed; size very small *Monomorium decamerum* Emery
43. Antennæ 11-jointed 44
Antennæ 12-jointed (10-jointed in *Pheidole perpusilla* Emery) . . 55
44. Thorax and petiole without any trace of teeth or spines; pronotum never angular 45
Metanotum nearly always armed with teeth or spines; when they are absent, the pronotum has angular humeri 48
45. Clypeus bidentate in front 46
Clypeus unarmed 47
46. Petiole distinctly pedunculate in front . . . . * **Monomorium** Mayr
Petiole not pedunculate . . . . **Xenomyrmex** Forel
47. Thorax unarmed, impressed in the region of the mesoëpinotal suture Vollenhovia Mayr
Thorax armed with spines and without an impression at the mesoepinotal suture . . . . Stereomyrmex Emery
48. Eyes prolonged obliquely downwards and forwards Oxyopomyrmex André
Eyes round or oval 49
49. Thoracic dorsum profoundly impressed at the mesoëpinotal suture 50
Thoracic dorsum little or not at all impressed 52
50. Humeri of pronotum rounded . . . . Huberia Forel
Humeri of pronotum angular 51
51. Antennal club 3-jointed, at least as long as the remainder of the funiculus . . . . Lophomyrmex Emery
Club indistinct, the last three joints much shorter than the remainder of the funiculus . . . . Podomyrma F. Smith
52. Frontal carinæ as long as the antennal scape . * **Tomognathus** Mayr
Frontal carinæ much shorter than the scape 53
53. Workers strongly dimorphic; integument shining, petiole pedunculate Machomyrma Forel[1]

[1] This group was established by Professor Forel as a subgenus of Liomyrmex; it has seemed to me to deserve elevation to the rank of a genus.

Workers not dimorphic 54

54. Petiole scarcely pedunculate in front, postpetiole armed below with a spine,[1] integument in great part smooth and shining
* Formicoxenus Mayr

Petiole with a short peduncle, postpetiole unarmed below; body in great part opaque . . . . * **Leptothorax** Mayr

55. Workers dimorphic, usually without forms intermediate between the large-headed soldiers and the workers; antennal club 3-jointed, longer than the remainder of the funicle (4-jointed in *Ph. granulata* Pergande); sting very feeble . . . . . . **Pheidole** Westwood

Workers monomorphic or dimorphic; in the latter case the extreme forms are connected by intermediates, and the antennal club is usually indistinct or shorter than the remainder of the funiculus 56

56. Petiole armed with spines above[2] 57

Petiole without a spine 58

57. Petiole with one spine . . . . Lordomyrma Emery

Petiole with two spines . . . . Atopomyrmex André

58. The last three joints of the antennæ are much shorter than the remainder of the funiculus and do not form a very distinct club 59

The last three joints of the antennæ form together a club about as long as the rest of the funiculus 63

59. Thoracic dorsum impressed at the mesoëpinotal suture; promesonotal suture usually distinct 60

Thoracic dorsum without any trace of suture or impression . . . 62

60. Posterior spurs pectinated . . . . * **Myrmica**

Posterior spurs simple or absent 61

61. Middle of clypeus projecting in an angle; epinotum unarmed, with a median impression which can receive the petiole; integument in great part shining (America) . . . . . Megalomyrmex Forel

Middle of clypeus angular in front; epinotum armed with spines: antennæ thick (Madagascar) . . . . . . Eutetramorium Emery

Clypeus of a different conformation, epinotum usually armed with teeth or spines (always without spines in Holcomyrmex)
* **Stenamma** Westwood
* Holcomyrmex Mayr[3]

62. Posterior spurs simple; petiole very long (Africa) Ocymyrmex Emery

Posterior spurs pectinated (America) . . . . **Pogonomyrmex** Mayr

[1] In *F. corsicus* Emery, the worker of which is unknown, the postpetiole of the female has only an obtuse tooth.

[2] In *Atopomyrmex ceylonicus* and *nodifer* the node of the petiole is merely angular in front.

[3] All the characters of the genus Holcomyrmex are found singly in one or the other forms of the genus Stenamma as I have defined this genus in my work on the ants of North America (*Zool. Jahrb. Syst.*, Bd. viii, p. 297). The teeth of the clypeus are indistinct in *H. muticus* Emery.

63. Clypeus armed with two ridges, which project forward in the form of teeth, rarely without teeth, but then the epinotum is quite unarmed; mesoëpinotal suture marked . . . . * **Monomorium** Mayr
Clypeus of a different conformation; rarely 2-toothed, but then the mesoëpinotal suture is indistinct 64
64. Inferior angles of the pronotum pointed . . . . . Rogeria Emery
Inferior angles of the pronotum rounded 65
65. Postpetiole campanulate, attached throughout by means of its whole posterior surface to the following segment; thoracic dorsum with neither suture nor impression . . . . **Macromischa** Roger
Postpetiole distinctly constricted posteriorly 66
66. The abdomen, seen from the side, is triangular; its anterior angle attached to the postpetiole; epinotal spines recurved forwards
Trigonogaster Forel
Of a different conformation 67
67. Without erect hairs, petiole pedunculate, with a rounded node; postpetiole usually very large . . . . * Cardiocondyla Emery
With erect hairs; which are usually clavate and microscopically denticulate . . . . * **Leptothorax** Mayr

The following genera are not included in this table: * Anergates Forel and **Epœcus** Emery, parasitic ants, which have no workers; Trichomyrmex Mayr, Tranopelta Mayr, * Oligomyrmex Mayr, Rhopalomastix Forel, Cratomyrmex Emery, of which the workers are unknown; and finally Pheidolacanthinus F. Smith, which was insufficiently characterized by its author and is unknown to me in nature.

4th Subfamily: DOLICHODERINÆ.[1]

1. Sting well developed; petiole with a long peduncle in front
Aneuretus Emery
Sting rudimental; petiole squamiform or nodiform, not pedunculate in front 2
2. Chitinous integument stiff and brittle, often strongly sculptured; thorax and scale often spinose or angular; gizzard without a calyx and with delicate cuticle, not furnished with cilia at the entrance
* **Dolichoderus** Lund
Integument thin and flexible, finely sculptured; thorax and petiole never spinose; gizzard of a different conformation 3
3. Body very slender; legs and antennæ much elongated, large or medium-sized species; gizzard without a calyx, furnished with cilia at the entrance (Australia) . . . . Leptomyrmex Mayr

[1] The genera of the Dolichoderinæ are in large part established on anatomical characters (structure of the gizzard) and the wing neuration; this renders the identification of isolated workers very difficult.

Body less slender; species nearly always small; gizzard with a reflected calyx 4

4\. Eyes very large, occupying one-third the side of the head
Turneria Forel

Eyes much smaller 5

5\. Cloacal orifice apical; petiole very low, without a distinct scale
Technomyrmex Mayr

Cloacal orifice inferior 6

6\. Scale of petiole very small and strongly inclined, or even altogether absent 7

Scale more or less inclined, but well developed 9

7\. Maxillary palpi 2–4-jointed, labial palpi 2–3-jointed; in the anterior wing of the female and male the transverse nervure joins the external branch of the cubital nervure (Europe, India, Australia)
* Bothriomyrmex Mayr

Maxillary palpi 6-jointed, labial 4-jointed 8

8\. Scale of petiole small but distinct in the worker (well developed in the female); in the anterior wing the transverse vein joins the external branch of the cubital vein; there is no closed cubital cell in the male, one only in the female; no discoidal cell; gizzard with a convex, 4-lobed calyx (a monotypic American genus) **Forelius** Emery

Scale rudimental or none; the transverse vein joins the cubital at the point of bifurcation; a single closed cubital cell, usually a single discoidal; gizzard with a depressed calyx without lobes
* **Tapinoma** Foerster

9\. Metanotum bearing a conical projection more or less distinctly developed; wings as in Forelius (American species) **Dorymyrmex** Mayr

Metanotum of a different conformation; wings with a discoidal cell 10

10\. Gizzard very short, with a great reflected calyx; no ocelli, stature but slightly variable . . . . Iridomyrmex Mayr

Gizzard at least as long as broad; stature highly variable; ocelli usually present in the large workers 11

11\. Thorax not impressed at the mesoëpinotal suture; no remarkable dimorphism in the workers; wings with two closed cubital cells
* **Liometopum** Mayr

Thorax impressed at the mesoëpinotal suture: workers often remarkably dimorphic; with a single closed cubital cell: transverse vein meeting the bifurcation of the cubital (American species)
Azteca Forel

The genus Linepithema Mayr, of which only the male is known, is not included in the above table.

5th Subfamily: CAMPONOTINÆ.

1. Mandibles long, linear, denticulate; eyes very large Myrmoterus Forel
Mandibles of a different conformation 2
2. Antennæ 11-jointed, or less 3
Antennæ 12-jointed 10
3. Clypeus projecting forward above the mandibles, eyes lateral, enormous, antennæ 8-jointed . . . . Gesomyrmex Mayr
Of a different conformation 4
4. Last joints of the antennæ forming a differentiated club; antennæ 9–10-jointed . . . . Myrmelachista Roger
Antennæ without a differentiated club 5
5. Frontal carinæ separated from each other by a greater distance than from the lateral borders of the head 6
Frontal carinæ closer to each other than to the lateral borders of the head 7
6. Eyes reniform, very large . . . . . Dimorphomyrmex Er. André
Eyes oval, of medium size . . . . Aphomomyrmex Emery
7. Maxillary palpi 2-jointed, labial palpi 3-jointed . . Acropyga Roger
Maxillary palpi 6-jointed, labial palpi 4-jointed 8
8. Metanotum and scale more or less 2-toothed or 2-spined
* Acantholepis Mayr
Metanotum and scale unarmed 9
9. Antennæ 11-jointed (Old World species) . . . * Plagiolepis Mayr
Antennæ 9-jointed, exceptionally 11-jointed; thorax short and thick-set (American species). . . . . **Brachymyrmex** Mayr
10. Eyes very large, occupying nearly the whole of the sides of the head
Gigantiops Roger
Eyes occupying less than one-half of the sides of the head . . . 11
11. Prothorax with an angular crest on either side; mesonotum prominent, in the form of a boss; gizzard as in Plagiolepis Notoncus Emery
Thorax of a different conformation 12
12. Antennæ inserted some distance behind the clypeus; gizzard with long straight sepals 13
Antennæ inserted very near the posterior edge of the clypeus . . 20
13. Maxillary palpi 5-jointed; petiole elongate, narrow; stature variable, but not dimorphic in the form of the head . Œcophylla F. Smith
Maxillary palpi 6-jointed; petiole short, squamiform or nodiform, often spinose or dentate 14
14. Dimorphism clearly marked in the size, form, and often in the sculpture of the head; stature usually very variable . . * **Camponotus** Mayr
No marked dimorphism in the workers 15
15. Eyes placed towards the posterior angles of the head
Opisthopsis Emery
Eyes on the sides of the head 16

16. Thorax and petiole without spines or teeth 17
Thorax and petiole, or the latter alone more or less spinose or dentate 18
17. Body thickset; head rounded behind (Australia, Papuasia) Calomyrmex Emery
Body slender; head narrowed behind (America) Dendromyrmex Emery
18. Body thickset; thorax without spines, its anterior angles rounded; petiole prolonged into a point on either side . Echinopla F. Smith
Body less thickset; thorax usually dentate or spinose (when this is not the case the body is shining jet black, and the scale of the petiole is quadridentate) 19
19. In profile, the mesonotum occupies the bottom of a deep cleft overarched by the metanotum; eyes supported laterally by a lobe of the head in the form of a blinder (œillère) . . . Hemioptica Roger
Mesonotum not depressed; eyes usually free, rarely with a distinct blinder . . . . * Polyrhachis F. Smith[1]
20. The last 4 to 5 antennal joints distinctly differentiated to form a club Myrmecorhynchus Er. André
No differentiated club 21
21. Calyx of gizzard reflected and surrounded by a muscular ring as in Plagiolepis (Australia, New Zealand, Chile) . Melophorus Lubbock
Sepals of calyx distinct and little or not at all reflected (except * Prenolepis, none of these genera are found in Australia or Chile) . 22
22. Clypeal fovea distinctly separated from the antennal fovea *** Prenolepis** Mayr
Clypeal fovea confluent with the antennal fovea, or feebly separated in Pseudolasius 23
23. Joints 2–5 of the funiculus shorter or not longer than the succeeding joints; ocelli usually absent 24
Joints 2–5 of the funiculus longer than the succeeding joints; ocelli distinct 25
24. Mandibles long, with oblique dentate blades; dimorphism very marked; head large in the worker major; clypeal fovea slightly separated from the antennal fovea (Sunda Islands and Moluccas) Pseudolasius Emery
Mandibles shorter, with less oblique blades; dimorphism scarcely or not at all perceptible (holarctic region) . . . *** Lasius** Fabricius
25. 4th joint of maxillary palpi nearly twice as long as the 5th *** Myrmecocystus** Wesmael
4th joint of the maxillary palpi a little longer than the 5th . . . 26
26. Mandibles with the apical margin broad and denticulate *** Formica** Linne
Mandibles narrow and pointed . . . . . . *** Polyergus** Latreille

[1] *P. simplex* Mayr has been found in Palestine. Mr. Edward Saunders sent me a specimen the provenience of which appears to be authentic.

ADDENDA.

Since the manuscript of the preceding paper was received, Professor Emery has made some changes in the subdivision of the genus Cerapachys.[1] He now divides this genus into five subgenera as follows: (1) Cerapachys (*sensu stricto*), with 12-jointed antennæ; (2) Parasyscia, with 11-jointed antennæ; (3) Oöceræa, with 10-jointed antennæ; (4) Syscia, with 9-jointed antennæ and the basal segment of the gaster but little longer than the postpetiole; (5) Cysias, with 9-jointed antennæ and the basal gastric segment very large. The more homogeneous genus Phyracaces is not cut up into subgenera.

In another recent paper[2] Emery describes a new genus, Ænictogiton, based on a male specimen of a peculiar doryline ant from the Congo (*A. forsiceps* Emery). As the name indicates, this insect is allied to Ænictus.

As a further addition, I may mention that Forel[3] has very recently described a remarkable new genus of Ponerinæ from Haiti under the name Emeryella. It resembles the extraordinary genus Mystrium in the structure of its mandibles. In other respects it is allied to Ectatomma. The following is a translation of Forel's diagnosis:

"**Emeryella** gen. nov.

"Mandibles, at first sight, very similar to those of the genus Mystrium, but without the two rows of teeth along their inner borders. They are linear, slightly depressed, longer than the head, feebly curved inwards, especially at their distal half, the basal half being nearly straight. Their bases are a little longer than their tips, which are obliquely truncated. There are only three teeth on the mesial border; the first is very broad, short, and obtuse, and not far from the base; the second, situated in the middle, is short and obtuse; the third is still smaller, and near the tip. The mandibles are nowhere canaliculated. They are inserted, like those of Mystrium, on the widely separated anterior angles of the head, so that they enclose a large empty space.

[1] Note mirmecologiche, *Rendiconto delle Sess. della R. Accad. delle Scienze dell' Istituto di Bologna* (Nov. 17, 1901), pp. 3–15.

[2] Note sulle Doriline, *Bull. della Soc. Ent. Ital.*, anno xxxiii, trim. 1 (1901), pp. 43–63.

[3] Variétés myrmécologiques, *Ann. Soc. Ent. Belg.*, tome xlv (1901), pp. 334–382.

"Apart from the above, all the characters are very similar to those of Ectatomma, especially of the subgenus Gnamptogenys. Antennæ 12-jointed. Eyes large, lateral. Frontal carinæ widely separated, short. Clypeus rounded behind. Promesonotal suture only slightly visible. Mesometanotal suture very deep, constricted. Pedicel of the abdomen like that of Gnamptogenys. Middle and hind legs with but a single spur, which is pectinated. Tarsal claws bidentate.

"This genus is undoubtedly very closely related to Ectatomma; but the structure of the mandibles is so peculiar and recalls so forcibly the group of Mystrium and Myrmecia that I feel fully justified in establishing the genus."

The type of the genus Emeryella is *E. Schmitti* Forel.

W. M. Wheeler.

PECULIAR STAGES OF FOLIAGE IN THE GENUS ACACIA.

CARLETON E. PRESTON.

THE development of foliage leaves in general appears, from the results of investigations made thus far, to be a regular increase in complexity, almost the same for the ontogeny of a single plant as for the race in historic development, as disclosed by fossil remains. As an especially good example may be mentioned a series given by Jackson ('99) illustrative of the history, both phylogenetic and ontogenetic, of Liriodendron. For the genus Acacia, Reinke ('96) gives a very comprehensive review of the development based upon the seedling forms and comparative study of the adults of the several subgenera, noting especially the phyllode-forming tendency.

As the first point which this paper aims to bring out deals with the bipinnate leaf and its development regardless of the phyllode, it may be well to call to mind the regular course of seedling leaf forms. The first leaf, after the cotyledons, is normally singly pinnate, with about four pairs of leaflets; the next is generally bipinnate, with but a single pair of pinnæ; further change is a mere addition of more such pairs along the main axis. A peculiar transition stage between the singly pinnate and the bipinnate is sometimes found in seedlings of *A. leprosa* Sieber when growing under cultivation. The shadow prints (Figs. 1 and 2) annexed show the nature of this peculiarity. The lower pair of leaflets only is replaced by a pair of strongly developed pinnæ, while the rest of the axis runs on singly pinnate and rather weak in structure. As a rule, no such continuation of the main axis is to be found.

In the case of Liriodendron, Jackson found some stages which could be regarded as progressive beyond the normal condition of the present species. Here the complexity was increased simply by augmentation of the number of lobes to the leaf.

This augmentation, as has often been shown, takes place in Acacias in the passage from the customary seedling leaf to the majority of bipinnate adults, a large number of pinnæ being added before the full-sized leaf is reached. But this mere addition of pinnæ scarcely seems to be the right interpretation of the increase in complexity if one compares the seedlings of Liriodendron and Acacia. What corresponds to the increase of lobes in the former is not so much the addition of pinnæ in the latter as the increase in degree of pinnation. Starting with a singly pinnate leaf, one arrives at a bipinnate form of remarkably fine structure in such species as *A. decurrens* Willd. But may there not exist a tendency toward triple pinnation in some of the forms? This question, suggesting itself, led to a rather careful search for evidence in its favor, with the result that in *A. decurrens* not a few leaves were discovered in which such a tendency was manifest. Of one of these leaves a shadow print is given (Fig. 3), showing clearly the third degree of pinnation on some of the basal leaflets of the pinnæ. How much of a prophecy this is of a fully tripinnate leaf in certain Acacias of some future epoch no one can really tell; the tendency, however, cannot be without significance.

FIG. 1. — Seedling of *A. leprosa*, showing abnormal third leaf. (Natural size.)

In his paper, which deals with animals as well as with plants, Jackson carries the same principle so far involved one step in advance in point of application. As a leaf develops base and tip first of all, he reasons that any change in shape which may add to its complexity will not appear at those points, but rather upon the proximal portions of the lamina. This he shows to be the case in Liriodendron, citing also several other examples in substantiation of his view.

In the case of the *A. leprosa* seedlings with abnormal development the lateral pinnæ may be regarded as further modifications of the proximal pair of leaflets of the ordinary first leaf of seedlings.[1] If this is, as seems probable, the right interpretation of such peculiar forms, it almost necessarily follows that the change in all the species at this stage is of the same nature, and that as a rule the higher, or more distal, leaflets upon the main axis lose the power to develop, on account of the greater strength of the newly developed lateral pinnæ. It may be worth while to state that these stages were found only after their prediction as the result of a course of reasoning, and were the direct objects of the search which led to their discovery.

FIG. 2. — Abnormal seedling of *A. leprosa*. (Natural size.)

The tendency toward triple pinnation is likewise, as may be easily seen by reference to the figure, only present upon the proximal leaflets of the pinnæ, and not at all to be found on the pinnæ near the tip of the leaf.

The final point to be discussed is the gradual metamorphosis to the phyllode. In seedlings where the change is gradual, as is the case in the great majority of species, but one pair of pinnæ is present at the time of its occurrence. In the abnormal seedlings shown, the prolongation of the axis is suppressed as the transition stages appear. In such cases it is possible to say with a high degree of certainty that the phyllode represents merely the flattened petiole. Next to be considered are the conditions of such forms as experience these changes later in life. *A. rubida* A. Cunn. and *A. heterophylla* Willd. have already been described by Reinke, and in his article one stage in the transition as it occurs in *A. heterophylla* is figured.

[1] *Cf.* seedling of Gleditsia, where such transition stages are frequent.

According to that author the change is merely a gradual flattening of the petiole, accompanied by the reduction of parts more distal. The stage represented in his paper is explained in the following words: "Wo es zu breiten Phyllodien mit nur einem Fiederpaar an der Spitze kommt, entsprach in den von mir gesehenen Fällen das Phyllodium einem nur oberseits geflügelten Blattstiel, das Fiederpaar dem untersten Fiederpaar eines Fiederblattes, Spindel und höhere Fiederpaare würden somit als abortirt anzusehen sein. Steht auf der Spitze eines Phyllodiums einmal ein zweipaariges Fiederrudiment, so pflegt die Spindel zwischen den beiden Fiederpaaren ungeflügelt zu bleiben" (p. 568).

Reinke is naturally giving only the results of his own observations, yet one cannot but draw the inference that a certain law is at least suspected, *viz.*, that only the petiole flattens in each case, and that at the same time the distal parts gradually cease to develop, until at last the stage is reached which this writer figures, after which the last pair of pinnæ fails to develop, and the phyllode is complete.

In the botanic garden of Harvard University there are two species of Acacia which show these transition stages in great abundance. They agree well in leaf characters with *A. rubida* and *A. heterophylla*, and will be discussed under these names, though full identification was not possible, owing to absence of flowers and fruit. Whether or not the determinations are right, the principle which they illustrate remains the same. Of both of these species the writer made a special examination during the spring of 1900, with a view to observing the different transition stages, their sequence and character. Upon re-reading Reinke's article in the summer of 1901, and finding there certain statements which in a way did not correspond with his results, he repeated the examination and ran across more peculiar forms which tend rather to disprove than to confirm the existence of any law governing such changes.

The first thing which appeared from these two examinations was that the method of reduction of the more distal parts described by Reinke, though indeed frequent, is perhaps not the most common of all. Rather more often an equal decrease

in size and final simultaneous disappearance of all the pairs of pinnæ was noted, as opposed to an unequal reduction starting

Fig. 3.—Leaf of *A. decurrens* showing tendency toward a triple pinnation. (Slightly reduced.)

at the distal end. In this *A. rubida* seemed to be very regular; in *A. heterophylla* various methods of change were shown. As

far as sequence is concerned, there appeared to be no definite order, series of transition stages running in both directions.

There was also found a fairly large number of stages which lead one to doubt greatly whether in all cases it is the petiole only which is transformed to the phyllode, and whether, if one pair of pinnæ persists at a certain stage, that pair is always the proximal one. The prints which follow may, to be sure, represent mere anomalies, but from their number, at least, they cannot but raise in one's mind a certain amount of hesitation to

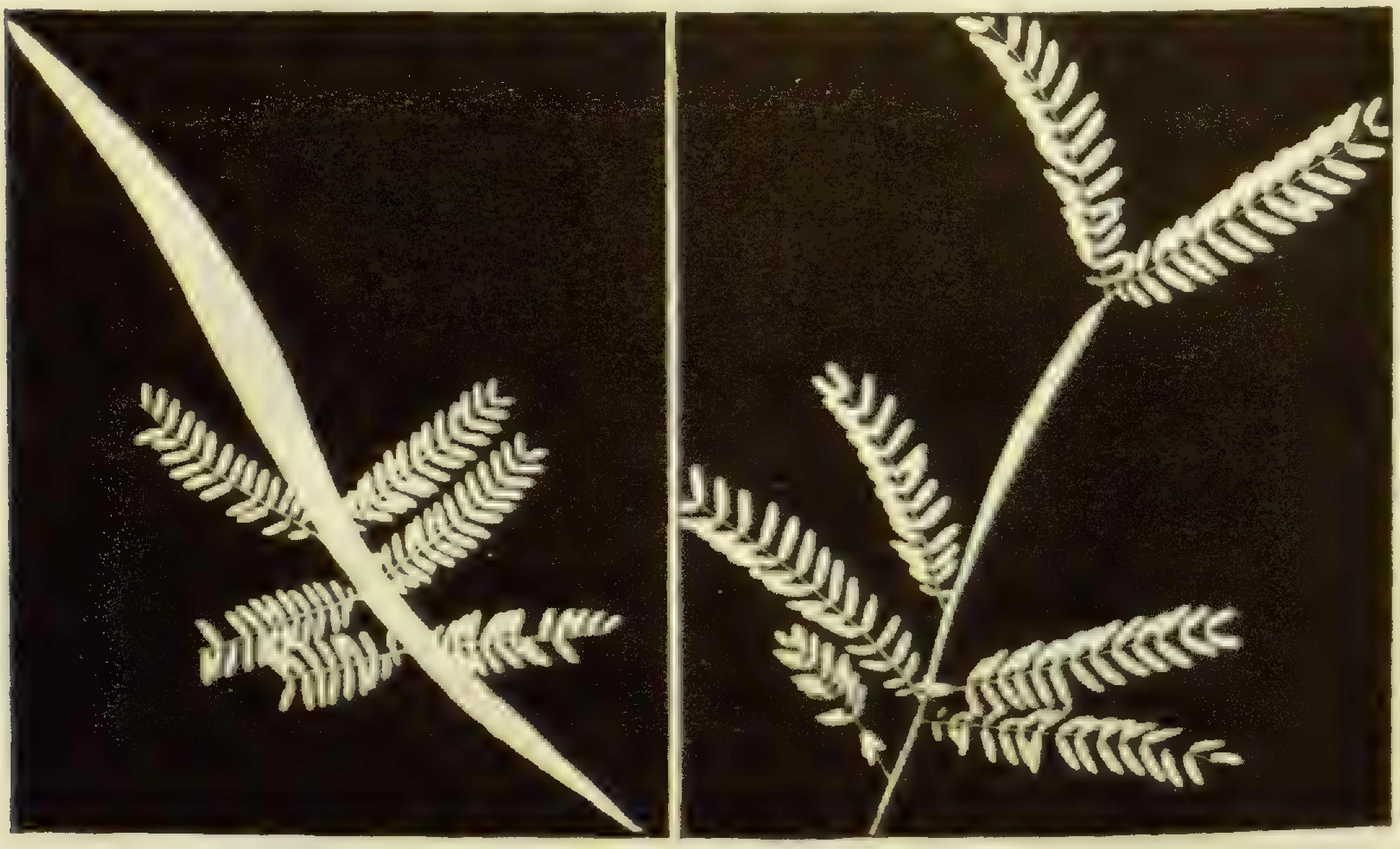

FIG. 4. FIG. 5.

FIGS. 4 and 5. — *A. heterophylla*, variation in transition to phyllode. (1/4 natural size.)

consider the existence of a law as to method in any way established. Here the flattening appears in some cases entirely on the distal portions without affecting the petiole, in others both petiole and rachis are involved to varied extents. How these are to be interpreted under one definite law seems incomprehensible.

It is hardly to be expected, however, that the process of reduction of parts is going to follow the same strictly regular line as that of advancement. The two are brought about by entirely different causes and are in no way comparable. Therefore the fact that such changes as those last described occur does not greatly invalidate the testimony of the earlier presented

data in support of a principle dealing with a progression. On the whole, the conditions of the seedlings of *A. leprosa* and of the leaf of *A. decurrens* stand strongly in favor of the existence

Fig. 6.

Fig. 7.

Fig. 8.

Fig. 9.

Fig. 10.

Figs. 6–10. — *A. heterophylla*, variations in transition to phyllode. (¼ natural size.)

of a regularly increasing complexity in leaf form, governed by fixed laws and repeated in an abbreviated form in plant ontogeny. To a certain extent also they add weight to Professor

Jackson's theory regarding stages in the development of a single leaf. The peculiar phyllode form rather discourages the idea of formulating any law covering phyllode formation, and lends an extremely potent meaning to Reinke's statement, "Der Wechsel von Phyllodien und Fiederblättern ist bei dieser Art [probably, as regards phylogeny, in others also] ein sehr mannigfaltiger."

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THE RELATION OF WIND TO BIRD MIGRATION.

C. C. TROWBRIDGE.

The influence of meteorological conditions on the migration of birds has been studied by a number of observers. Among the important monographs on the subject is that of Prof. W. W. Cooke, "Bird Migration in the Mississippi Valley," in which it is shown clearly that migratory waves of birds accompany changes of temperature. The wind directions and velocities were recorded in the paper mentioned but the author did not regard the migratory movements to be due to the direct effect of the wind, which was considered merely as the chief cause of the temperature changes.

The same view is held by Dr. W. Stone in his "Birds of Eastern Pennsylvania and New Jersey," in which by a series of curves the fact is illustrated that migratory waves of birds follow closely changes of temperature.

The author of the present paper believes that the bird waves described by the above observers were largely due to the direct influence of favorable winds, and that the wind is a more important factor in bird migration than it is generally regarded.

That the subject has not received much attention is shown by the recent valuable review on bird migration by Dr. F. H. Knowlton in *Popular Science Monthly*.[1] In the paper referred to no mention of the relation of the wind to bird migration is made. In fact, the word "wind" is not used in the thirteen pages of the article.

In considering the relation of meteorology to bird migration, general as well as local atmospheric conditions must be studied, and it is important that the atmospheric conditions where the birds start on their migratory journeys be determined, if possible. Furthermore, the number of new arrivals

[1] Knowlton, Dr. F. H. The Journeyings of Birds, *Pop. Sci. Mon.*, vol. lx. No. 4, p. 323.

recorded in any locality is not always a safe criterion of the migratory movement of birds, because adverse meteorological conditions often tend to retard or stop the migrations and bring certain species under notice which, with favorable conditions, would have passed by unobserved.

A previous paper by the author, "Hawk Flights in Connecticut,"[1] contained an account of flights of hawks which had occurred along the southern border of Connecticut during the autumn migrations, in which the results were presented of observations covering a period of nine years, from 1885 to 1894.

The present paper is an account of further observations on the migrations of hawks and on the effect of the wind on the migrations of various other species of birds. It is necessary to refer to the contents of the previous paper on the subject, and the principal facts given in it are as follows:

It was shown that flights of hawks occurred in September of almost every year in southern Connecticut, consisting of different species, some of which passed along the coast singly, others in flocks of from twenty to two hundred. The hawks were most numerous at from one half to one mile inland from Long Island Sound, along the first low hills back from the coast.

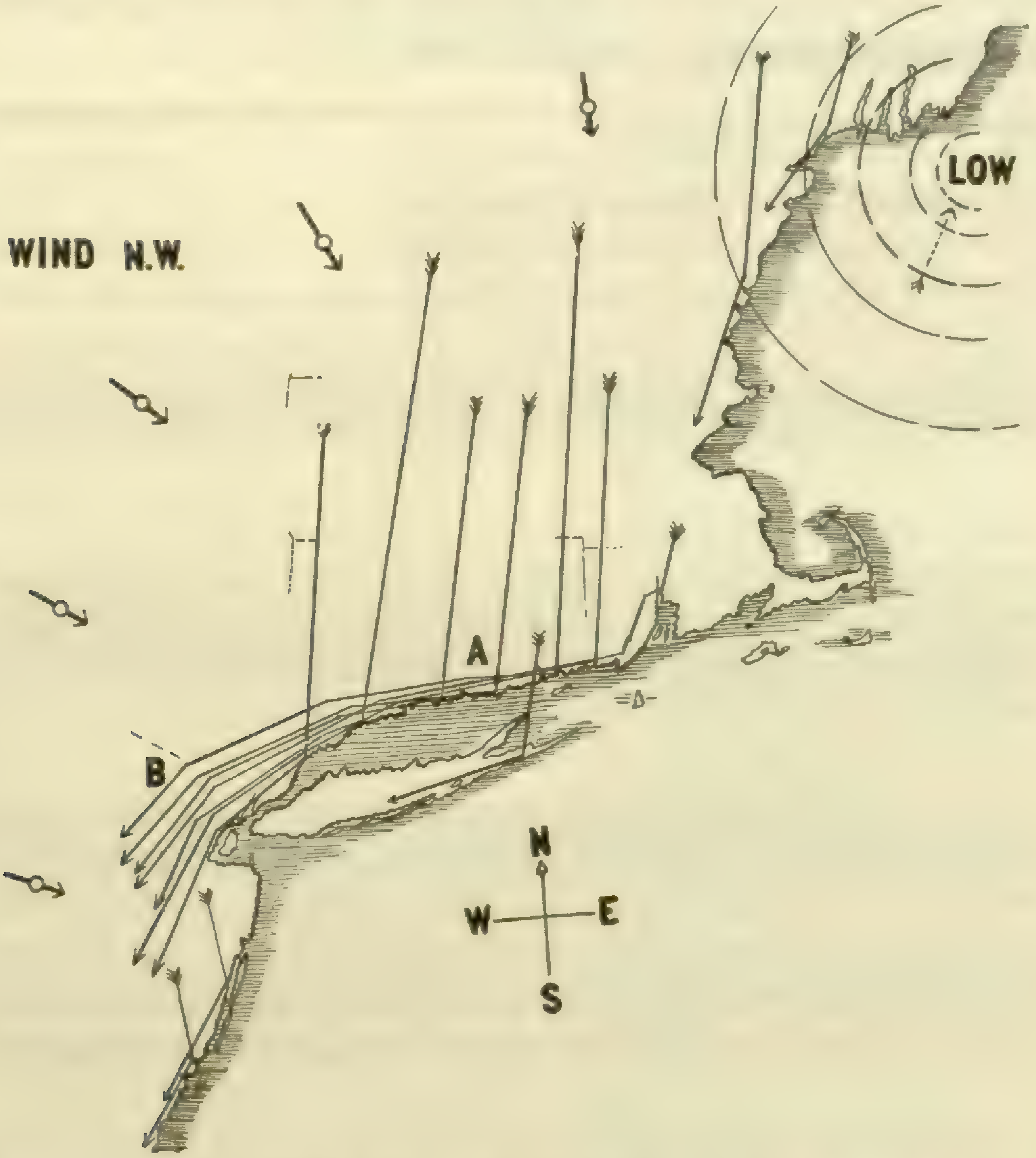
Twenty-two hawk flights were recorded in nine years, and in each case notes were made on the relative abundance of the different species of hawks seen migrating. A record was kept of the meteorological conditions on the days when the flights in question took place. It was found that on the days when the flights occurred the wind blew from the north or northwest, and usually with considerable velocity. On seven days the wind blew at the rate of over twenty miles an hour, and on eight other days not less than fifteen miles. The greatest flights occurred on three days, when the velocity of the wind was about forty miles per hour during part of the day.

An explanation of the cause of these autumn flights of hawks was given, and the theory advanced has been fully verified by

[1] *The Auk*, July, 1895.

subsequent observations. The cause of the flights was stated to be as follows:

Hawks drift with the wind when soaring, and as they soar continually, their movements during migrations are largely dependent on the direction of the wind. In the present case hawks migrating in autumn in New England drift south or



MAP I. — COAST LINE OF THE NEW ENGLAND STATES AND NEW JERSEY.

The long arrows indicate the general direction of migration of hawks and many other land birds in the autumn, when the wind is northwest, illustrating why these birds congregate at the coast line of Connecticut.

The broken circles drawn about a point off the coast of Maine are low-pressure isobars indicating a storm center traveling northeast and causing the northwest winds over the northeastern part of the United States. At the point *A* the hawks follow a narrow path and fly low: at *B* the hawks gradually separate, usually flying higher as the wind becomes more favorable.

southeast until they reach the Atlantic coast line. They then turn westward and follow the shore until they have reached New York and New Jersey, where they gradually separate and pass on southward. Thus the hawks migrating from a large area of country — eastern Canada, New England, and perhaps northeastern New York — are forced to travel along a narrow coastline path at right angles to the main direction of their migration.

A condensed table of flights which occurred from 1885 to 1895 is given below. It has already been published in part, but it is necessary in the present paper for the purpose of showing certain new facts that will be presented.

The meteorological data in the table as formerly given was that for New Haven, Conn., where the observations on hawk flights were made. In the table as given at present the observations of the U. S. Weather Bureau taken at Boston are substituted for those taken at New Haven. This change is made because the former station is nearer the locality where the hawks start on their migratory journey than the latter place. Another column has been added to the table for the purpose of showing the effect of temperature changes on the migratory movements of the hawks. The meteorological data in the tables have been kindly furnished by the Boston office of the U. S. Weather Bureau.

It is difficult to determine the number of hawks that pass a given point on the Connecticut shore, during a moderately large flight in September. An estimate, which appears to the author to be conservative, is that over 15,000 of them pass New Haven in one day. The sharp-shinned hawks outnumber the other species several times over. The broad-winged hawks are next in abundance, then the ospreys and marsh hawks which are about equally numerous.

Observations show that many ospreys and marsh hawks cross to Long Island, but it is evident that the main flight of hawks is along the Connecticut shore.

Since 1894 observations have been continued on flights of hawks in Connecticut in autumn, and in New Jersey in spring, which have resulted in bringing to light additional facts relating to the effect of wind on the migration of birds.

TABLE I.[1]

LIST OF MIGRATORY FLIGHTS OF HAWKS WHICH HAVE OCCURRED IN SOUTHERN CONNECTICUT DURING THE YEARS 1885–95. METEOROLOGICAL RECORDS, BOSTON, MASS.

Date.	Weather.	Wind Direction.	Wind Velocity; Miles per Hour.	Temperature Change in Past 24 Hours	Remarks.
Sept. 23, '85	Rain	N.W.	14	−7	Moderate flight; *Falco sparverius* common.
Sept. 18, '86	Clear	N.W.	21	−8	A great flight of small hawks and various other land birds.
Sept. 22, '86	Partly cloudy	N.W.	10	−2	*Buteo latissimus* abundant.
Sept. 16, '87	Clear	N.	12	−5	A great flight all day.
Sept. 17, '87	Clear	N.W.	8	−7	*Buteo latissimus* abundant early in the morning.
Sept. 24, '87	Clear	N.	14	−10	*Buteo latissimus* abundant, also *Accipiter velox*.
Oct. 19, '87	Cloudy	N.	10	−11	No large flight, but almost all the migrant hawks observed.
Sept. 10, '88	Cloudy	W.	9	−2	*Accipiter velox* abundant.
Sept. 22, '88	Cloudy	N.	24	−3	Moderate flight.
Sept. 22, '89	Clear	W.	14	−8	
Sept. 28, '89	Clear	W.	14	−5	Very large flight.
Oct. 15, '89	Clear	N.	19	+5	Moderate flight; *Accipiter velox* plentiful.
Sept. 18, '90	Cloudy	W.	13	−2	40 hawks killed; *Buteo latissimus* abundant.
Sept. 21, '90	Clear	N.W.	14	−16	Moderate flight.
Sept. 23, '90	Clear	W.	14	+2	*Pandion haliætus carolinensis* abundant.
Sept. 24, '90	Clear	N.W.	20	−8	Small flight.
Sept. 8, '91	Clear	W.	11	−2	Hawks increasing in numbers.
Sept. 9, '91	Clear	W.	10	−5	A large flight; killed over 20 hawks.
Sept. 14, '91	Clear	W.	11	+2	Small flight.
Oct. 21, '92	Cloudy	W.	9	−3	Small flight of *Accipiter velox*.
Sept. 20, '93	Clear	W.	8	−1	Large flight; *Buteo latissimus* abundant.
Sept. 21, '93	Clear	N.W.	12	−12	Great flights of adult *Buteo latissimus*.
Sept. 13, '95	Cloudy	N.	14	−10	Large flight.
Sept. 14, '95	Clear	N.W.	14	−11	Great flight of *Buteo latissimus*.

[1] The flights of hawks recorded in the above table were observed at New Haven, Conn., and the meteorological data given is that for Boston, from 1885 to 1887 at 7 A.M., from 1888 to 1895 at 8 A.M. The reason for giving the meteorological conditions for Boston has been already explained.

During September, 1895, daily observations were made on the migration of hawks at New Haven, Conn., when as far as possible the variety, as well as the number of hawks which were seen on each day, was noted. A record was also kept of the meteorological conditions for the same period, particularly the state of the weather and the velocity and direction of the wind.

The observations extended over a period of twenty-three consecutive days, from September 6 to September 29, this being the month during which five or six species of hawks migrate southward. The object of these observations was to ascertain if wind from a southerly quarter not only retarded the migration, but practically stopped it, and also to determine if the migratory movement ceased when there was little or no wind. The observations were as follows:

Sept. 6. Fair; wind N.E., 11 miles. 1 bald eagle; 1 fishhawk; 2 sharp-shinned hawks.

Sept. 7. Fair; wind N.E., 16 miles. 1 broad-winged hawk.

Sept. 8. Cloudy; wind S.W., light. 1 sharp-shinned hawk.

Sept. 9. Cloudy; wind S., light. 1 large hawk; 1 sparrow hawk.

Sept. 10. Warm and hazy; wind S., very light. No hawks seen.

Sept. 11. Cloudy; wind S.W., 10 miles. 1 fishhawk; 1 sparrow hawk; 3 sharp-shinned hawks.

Sept. 12. Fair; wind S.W., light. No hawks seen.

Sept. 13. Clear, cool; wind N.N.W., 22 miles. Several flocks of broad-winged hawks of from ten to fifteen observed; 4 adult bald eagles; hundreds of sharp-shinned hawks, and fish, sparrow, and marsh hawks common.

Sept. 14. Clear, cool; wind N. by W., fresh. All the hawks which were observed yesterday, common to-day. A number of eagles also seen. Broad-winged hawks exceedingly abundant; flock after flock passed westward over New Haven, Conn. Eighty-five were counted in one flock, while another equally large body of them was observed at the same time. These hawks passed over the city continually from 7 A.M. until 3 P.M.

Sept. 15. Clear, cool; wind N., light. A few hawks observed migrating at a high altitude.

Sept. 16. Cloudy; wind N. to S.W., light. No hawks seen.

Sept. 17. Clear; wind S., 5 miles. 2 fishhawks; 1 sharp-shinned hawk.

Sept. 18. Light rain; wind N.E. No hawks seen.

Sept. 19. Light rain; wind S., light. 1 fishhawk.

Sept. 20. Cloudy; wind S.W., light. No hawks seen.

Sept. 21. Clear, warm; wind W. No hawks seen.
Sept. 22. Clear; wind N.W., light. A few sharp-shinned hawks.
Sept. 23. Wind W. by N., light. No hawks seen.
Sept. 24. Cloudy; wind N., 12 miles. A small number of broad-winged and sharp-shinned hawks and one each of the following species: fish, marsh, and sparrow hawks.
Sept. 25. Stormy; wind S.E., light. No hawks seen.

MAP II. — COAST LINE OF THE NEW ENGLAND STATES AND NEW JERSEY.

In this case the long arrows indicate the direction of migration of hawks in the autumn when the wind is northeast. A storm center is indicated by low-pressure isobars south of the New Jersey coast, causing northeast winds in New England. When the wind is northeast there is usually a small flight of hawks along the Connecticut shore, as indicated.

Sept. 26. Fair; wind S.W., 10 miles. 2 fishhawks; 1 sparrow hawk.
Sept. 27. Cloudy; variable light winds. No hawks seen.
Sept. 28. Clear; variable light winds S.E. 1 fishhawk.
Sept. 29. Stormy; wind E. 1 fishhawk.

In the table given below are placed the days, thirteen in number, taken from the above list, when not more than one hawk was seen. The meteorological conditions at New Haven on these days is also recorded in the table. An inspection of the observations shows that no strong northwest winds occurred on any of these days.

TABLE II.

Date, 1895.	Weather.	Wind Direction, Lower Strata.	Wind Velocity, Miles per Hour.	Number of Hawks observed.	Direction of Upper Strata.
Sept. 7	Fair	N.E.	15	1	—
" 8	Cloudy	S.W.	18	1	—
" 10	Fair	Variable	—	0	—
" 12	Fair	S.W.	7	0	—
" 16	Cloudy	S.W.	7	0	—
" 19	Rain	N.E.	6	1	N.E.
" 20	Cloudy	S.W.	5	0	W.
" 21	Clear	W.	2	0	—
" 23	——	W.	1	0	W.
" 25	Cloudy	E.	Light	0	N.
" 27	Cloudy	N.	4	0	—
" 28	Clear	N.	9	1	—
" 29	Cloudy	N.E.	7	1	S. by W.

It has been observed that the direction of the movement of the upper strata does not influence the migratory movement, and that the surface currents are those in which the hawks usually migrate. In the last column of Table II the direction in which the upper strata were moving is given in a few cases. The table, of course, is not meant to show the number of birds migrating, but it gives an idea of the number of hawks observed by one constantly watching for them.

In the table given below, the U. S. Weather Bureau observations are those for Boston on the days given in Table II. It is evident from a comparison of these two tables (II and

III) that the meteorological conditions on nearly all days were very unsettled in New England, and that although in a few cases the wind direction, for a time at least, was favorable for a migration of hawks near Boston, the adverse conditions in Connecticut stopped the migratory movement.

TABLE III.

UNITED STATES WEATHER BUREAU OBSERVATIONS AT BOSTON, MASS., 8 A.M., SEPTEMBER, 1895.

Date, 1895.	Weather.	Wind Direction.	Wind Velocity, Miles per Hour.	Temperature Change in Past 24 Hours.
Sept. 7	Cloudy.	N.	13	+3
" 8	Cloudy.	N.W.	14	−1
" 10	Cloudy.	N.W.	3	+1
" 12	Cloudy.	N.W.	5	−2
" 16	Cloudy.	S.W.	12	+3
" 19	Cloudy.	N.	8	+4
" 20	Partly cloudy.	W.	12	+6
" 21	Clear.	N.	2	−1
" 23	Clear.	W.	7	+2
" 25	Clear.	N.	3	−2
" 27	Cloudy.	W.	12	−3
" 28	Clear.	N.	7	−10
" 29	Clear.	E.	18	+2

In Table II, as well as in Table III, the directions and velocities of the winds were taken from the local U. S. Weather Bureau records.

There is a slight discrepancy between some of these observations and those taken by the author and given previous to Table II. These differences are due to variations in the direction of the wind on certain days. For example, part of the morning of September 28, Table II, the wind direction was S.E. and light, while at the time of the U. S. Bureau observation it was N., 9 miles. The table on the following page shows the days of September, 1895, when flights of hawks occurred.

TABLE IV.

DATE, 1895.	WEATHER (New Haven).	WIND DIRECTION (N.H.).	WIND VELOCITY (N.H.).	NUMBER OF HAWKS OBSERVED.
Sept. 13	Clear.	N.N.W.	22	Large flight.
" 14[1]	Clear.	N.W. to N.	9	Very large flight.
" 15	Clear.	N.	13	Small flight.
" 24	Cloudy.	N.	12	" "

The observations made of flights of hawks that have occurred during a period of fifteen years show that they have taken place on nearly every date during September, after the 5th of that month. This is readily seen from Table I, which gives the flights of hawks which occurred during the years 1885 to 1895. It is evident that there is no special date on which the hawks migrate during the month of September. Their appearance in large numbers must be due therefore to some special influence. This has already been shown to be the wind from the northwest quarter, in which the birds drift southeastward to the coast line, making necessary their flight along the shore of Connecticut.

The observations made during September, 1895, show an additional fact; if hawks migrated regularly in New England throughout September without regard to the direction of the wind, then there would be a small continual flight of hawks in southern Connecticut during the entire month, due to the peculiar shape of the coast line. Such would be the case, because hawks migrating in a southward direction through the New England States would eventually reach the southern border of Connecticut, where it would be necessary for them to fly westward along the coast, producing the small daily flights referred to.

It has been proved that no daily flight takes place, only a few stray hawks being observed. Moreover, at any time

[1] In Table IV the velocity of the wind at 8 A.M., September 14, is given as 9 miles at New Haven. At Boston, however, at the same time the wind was N.W. 14 miles, and at New York 12 miles.

On September 24 the wind at Boston was N. 18 miles, and at New York N.W. 14 miles.

during the month a flight of many thousands of hawks will occur if the wind turns to the northwest quarter, the hawks appearing within several hours after the change of the wind takes place. This is shown by the following example:

The morning of September 18, 1890, was warm and calm. In the most favorable station for observations near New Haven, between sunrise and nearly eight o'clock, only two hawks were observed. About eight o'clock a breeze started up from the northwest, and a great number of hawks soon appeared, over forty of which were shot. Again, on September 12 and 23, 1895, no hawks were seen, but on the dates immediately following, September 13 and 24 respectively, hawks appeared in large numbers.

The significance of these facts is that the wind not only changes the line of flight of the migrating hawks, but that it is also the immediate cause of their migratory movement.

In further proof of this statement it has been observed that when a northwest wind blows for three days in September, on the third day hawks are not abundant; for all of those hawks which are ready to fly southward start at once when the wind begins to blow in a favorable direction.

A second wind from the northwest quarter, after a week of southerly winds or calm, will produce a second flight of hawks, usually of shorter duration than the first.

A third favorable wind will seldom cause another large September hawk flight, although every wind from the north or northwest throughout the autumn produces a greater or less abundance of hawks along the Connecticut coast.

The expression "the immediate cause of migratory movement," used in the present paper, perhaps requires an explanation: If a favorable wind, acting as a physical agent, is used by birds as a means of migration, it is also an immediate cause of their migratory movement because it determines the time of their migration.

By the expression "favorable wind" is meant a wind which when resolved into components with respect to the migratory direction shows one favorable to the migration.

EFFECT OF TEMPERATURE CHANGES ON THE MIGRATORY MOVEMENTS OF HAWKS.

To what extent these flights of hawks and other land birds are due to changes of temperature is difficult to determine. An examination of the data given in Table I, however, shows the following facts:

1. The direction of the wind at Boston at the 7 and 8 A.M. observations on days when twenty-four flights of hawks occurred was as follows: north, six days; northwest, eight days; west, ten days. Total, twenty-four days.

2. The mean velocity of the wind for the twenty-four days (morning observations) was thirteen miles an hour, maximum twenty-four miles per hour, minimum eight. (In many cases the wind increased considerably during the day.)

3. Mean change of temperature in past twenty-four hours of twenty-four days on which flights occurred was – 5.7 degrees.

4. The number of days with higher temperature than the preceding day was four (+ 5 + 2 + 2 + 1).

5. The number of days with lower temperature than preceding day, but less than three degrees change, was six (– 2 – 2 – 3 – 2 – 2 – 3).

From the above it is seen that on ten days of the twenty-four in the table the temperature was either higher than the preceding day (in four cases) or lower by not more than three degrees. It seems evident, therefore, that the chief causes of the great migratory movements that occurred on the days given in the table were the favorable winds and not diminution of temperature.

TIME OF DAY DURING WHICH HAWKS MIGRATE.

When hawks occur in flights during the autumn migrations they usually make their appearance some time after sunrise and continue flying all day, the maximum of the flight occurring in the forenoon in southeastern Connecticut and in the afternoon near the New York state line. In the former locality the sharp-shinned hawks begin to appear soon after sunrise and

the broad-winged hawks usually not until about eight o'clock, unless there has been a favorable wind the previous day, in which case the flight begins earlier. Many other species of birds, — woodpeckers, thrushes, blackbirds, etc., — apparently acting under the same influence that produces the migration of hawks, namely, the favorable winds, make their appearance before sunrise near the Connecticut shore and are abundant for a few hours only, because they soon fly back into the country to feed. The birds mentioned are known to migrate at night. Most species of hawks, on the contrary, appear to migrate during daylight only. This point is in agreement with observations made by others.

The Migration of the Broad-Winged Hawk.

The behavior of the broad-winged hawks when they are migrating in flocks is peculiar. If, for example, these birds are soaring together in a flock of from twenty-five to fifty, one bird will be seen to separate from the flock, set its wings, and sail away in the migration direction (west in southern Connecticut). Presently another will follow at an interval of a few hundred feet; then another, until finally the entire flock is observed to be sailing with set wings in single file. When the hawks have sailed from a half mile to two miles this way, they collect together and begin to soar again in an area of about one or two acres and continue circling until they have attained a considerable height. The peculiar manœuver is then repeated.

The broad-winged hawk is the only one of the entire family that shows a decided tendency to collect in large flocks during the migration. Red-tailed hawks are sometimes observed in small flocks.

Hawks blown out to Sea.

Strong northwest winds are undoubtedly the cause of many birds being blown out over the Atlantic Ocean and lost during the southward migration. Hawks form no exceptions, for instances like the following are not unfrequently reported:

When the Munson line steamship *Curitiba*, bound for New York, reached lat. 30° N., long. 70° 30′ W., on Oct. 11, 1900, "five ospreys came on board; two of them were shot, one was captured, one alighted on the after-deck boat and then fell into the sea, and the remaining one fell down the funnel. At dusk on the following day two more hawks were captured." These facts were given to the author of this paper by Captain Hoppe of the *Curitiba*.

When the birds were first seen the *Curitiba* was 500 miles from Florida and 400 miles from Cape Hatteras. According to the U. S. Weather Bureau observations taken at 8 A.M. on October 10, at Cape Hatteras, the wind was north, 28 miles per hour, and on October 11, north, 14 miles per hour. At Boston, on October 11, the wind was northwest, 24 miles per hour.

These strong offshore winds were unquestionably the cause of the appearance of the hawks far out at sea. The *Curitiba* also encountered a large number of bats which had evidently blown out to sea by the northwest wind.

Migrating Periods of Various Species of Hawks in Autumn.

In the table on the opposite page the periods when a number of species of hawks migrate southward in the latitude of Connecticut are given.

Widespread Effect of Storms.

It is well known that high north and northwest winds are directly due to centers of low barometric pressure lying to the eastward.

In the northern hemisphere the motions of the lower strata of the atmosphere about centers of low barometric pressure are counter-clockwise. These low areas are known as storm centers, and in the eastern part of the United States they usually travel in a northeasterly direction. A storm of moderate intensity is shown by Map III, which is an approximate representation of the U. S. Weather Bureau map of

TABLE V.

Species.	Date.	Abundance.
Fishhawk (*Pandion haliætus carolinensis*)	Sept. 1–Oct. 15	Abundant.
Marsh hawk (*Circus hudsonius*)	Sept. 1–Oct. 10	Very common.
Pigeon hawk (*Falco columbarius*)	Sept. 10–Oct. 10	Regular, but not common.
Sparrow hawk (*Falco sparverius*)	Sept. 10–Oct. 10	Very common.
Sharp-shinned hawk (*Accipiter velox*)	Sept. 5–Oct. 15	Very abundant.
Cooper's hawk (*Accipiter cooperi*)	Sept. 5–Oct. 15	Very common.
Goshawk (*Accipiter atricapillus*)	Oct. 25–Nov. 25	Occasional, sometimes common in November.
Broad-winged hawk (*Buteo latissimus*)	Sept. 10–Oct. 1	Very abundant.
Red-shouldered hawk (*Buteo lineatus*)	Oct., Nov. (?)	Common.
Red-tailed hawk (*Buteo borealis*)	Oct. 20–Dec. 1	Very common.

September 18, 1900. The map shows the extent of country throughout which north or northwest winds prevailed at 8 A.M. on that date. These winds were reported throughout an area of over 800,000 square miles, and their recorded velocity varied from ten to forty miles per hour.

Owing to these winds a large southward flight of birds must have occurred on the given date in eastern Canada and in the eastern part of the United States.

This map is employed to show also the general migration directions of various water birds in the eastern part of the United States. The arrows *AA* show the probable line of flight of many ducks, swans, and shore birds from the interior of Canada to the North Carolina coast. Those marked *C* show the sea flight of many water birds from Labrador, as noted in the Gulf of St. Lawrence region by the author, and those marked *B* indicate the direction of the coast line migration.

The converging arrows *AA* and *C* explain the abundance of water fowl along the coast of North Carolina.

FLIGHTS OF HAWKS IN SPRING.

From the middle of March until the first part of May flights of hawks occur along the Atlantic coast. These flights appear to be greatest over the hills near the New Jersey coast, but occur also at some distance in the interior. Near Paterson there is a hill about 500 feet high, part of the Watchung range, over which large numbers of hawks pass in the spring. On the west slope of this hill many pits and brushwood blinds are made every year, both in the woods and in the open ground, and are occupied during March and April by men and boys who make a practice of killing hawks for New York and New Jersey taxidermists. The author has witnessed several flights of hawks on this hill, which is the first high land back of the coast.

The most favorable wind for a flight is west, or a little south of west. The red-tailed hawks are the first to appear in the spring, and the sharp-shinned and the broad-winged hawks are the last. The periods when some of the hawks may be expected are given below :

Fishhawk, latter part March to May 1.
Marsh hawk, April.
Sharp-shinned hawk, April 10–May 10.
Cooper's hawk, April.
Broad-winged hawk, April 10–May 5.
Red-tailed hawk, March 1–April 10.

Observations described above seem to warrant the following conclusions :

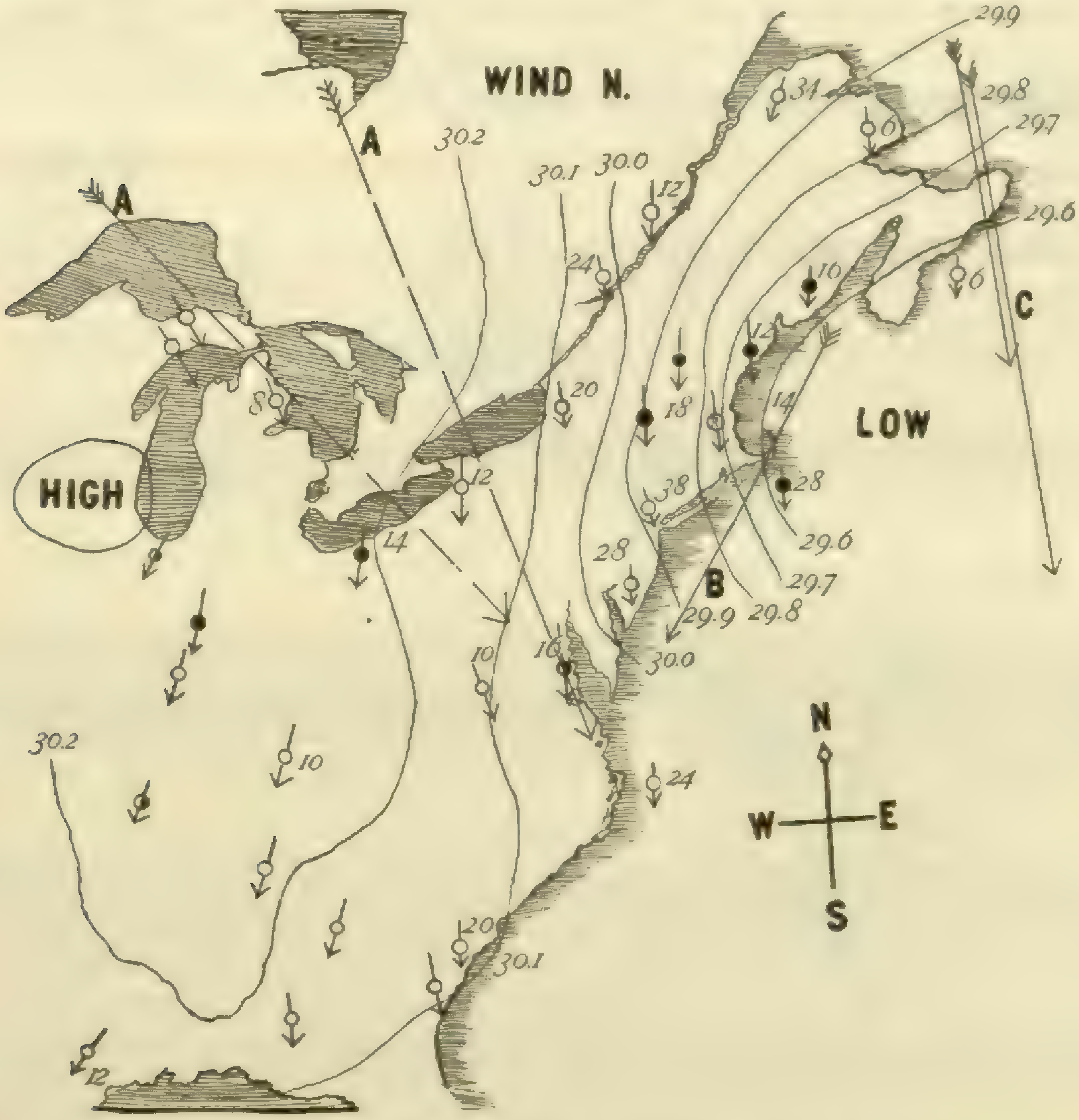
1. That the migratory movements of hawks are largely determined by the direction of the wind, hawks regularly depending on favorable winds as a help in migration.

2. That an adverse wind not only retards the migratory movement, but that it almost completely arrests it.

3. That the migratory period of the various species of hawks lasts for from about fifteen days to one month ; during this time the migratory movements take place on days when favorable winds occur.

4. When the wind is favorable and approximately parallel to the direction of migration, hawks fly and sail at a high altitude and occasionally soar in circles.

5. When the wind is favorable but nearly perpendicular to the migratory direction (the favorable component being small),



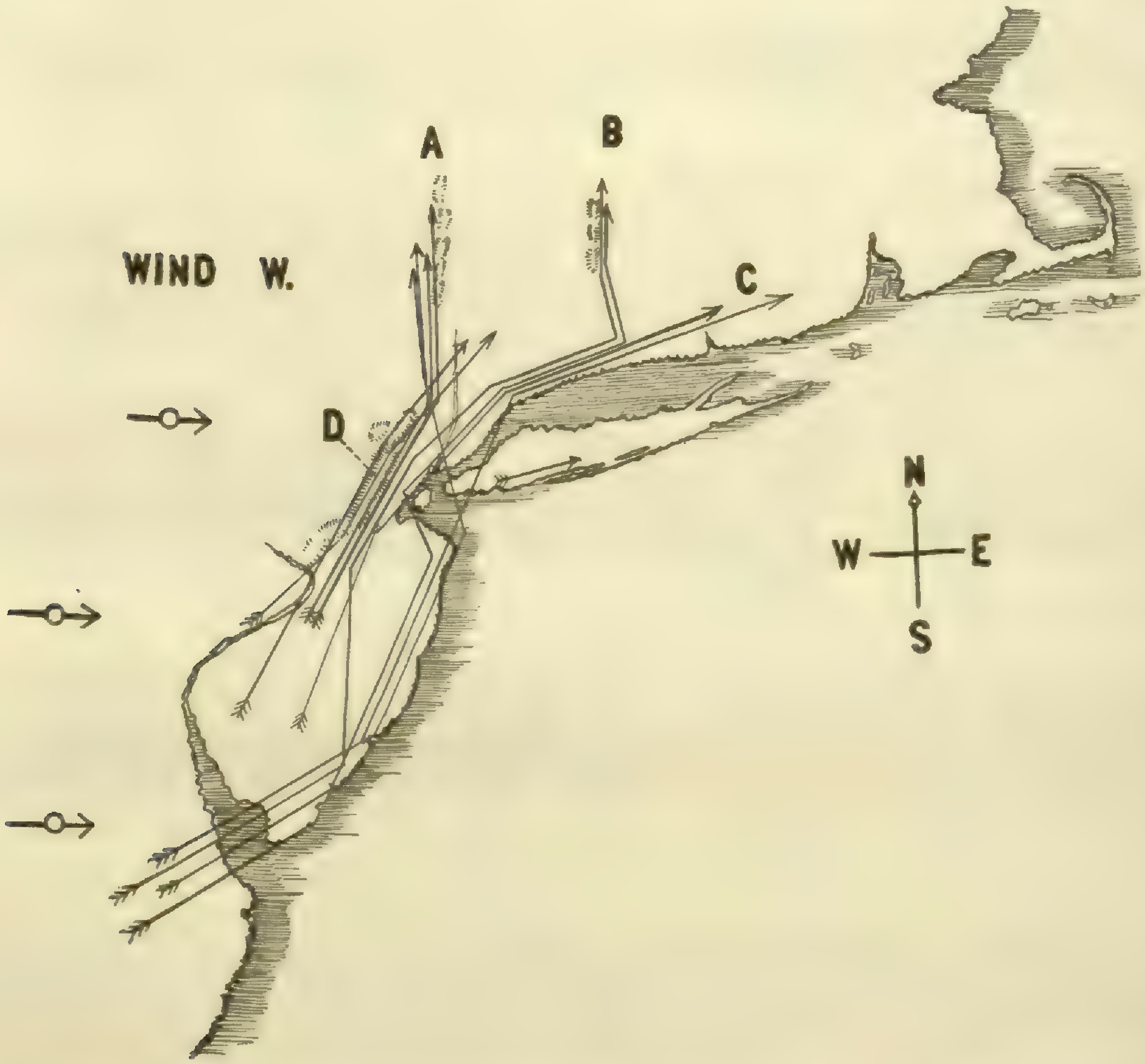
Map III. — Eastern Canada and Eastern United States.

The dotted lines are the isobars of September 18, 1900. A low barometric pressure is centered off the Maine coast. The small arrows indicate the direction of the wind, and its velocity in miles per hour is given in a number of cases. The mean velocity of the wind records on the map as it is given here is over seventeen miles per hour.

hawks fly low and soar continually, often alternating soaring with the wind and flying or sailing nearly against it.

6. That hawks migrate during the daylight, and, other conditions being the same, they are most abundant in migratory flights when the atmosphere is clear.

7. When a migratory flight of hawks takes place, continued favorable winds exhaust the number of hawks ready to make the migratory journey, but a second favorable wind about one week later may cause a second flight equal in magnitude to the first.



Map IV. — Coast Line of Southern New England, New Jersey, and Delaware.

The long arrows indicate the direction of migration of hawks and various other birds in the spring, when the wind is west or southwest. Owing to the fact that the coast line is nowhere at right angles to the direction of migration, the flight is not in a narrow path, as along the Connecticut shore in autumn, but ten or fifteen miles wide in the northern part of New Jersey.

The arrows marked *A* show a flight up the Hudson valley, those marked *B* a flight up the Housatonic valley in Connecticut, and those marked *C* a general northeast flight in New England. The Watchung range, along which many hawks migrate, is indicated by *D*.

8. That a favorable wind, when the favorable component is small, may cause decided deviations of the course of the migrating birds from the main migratory direction.

These conclusions apply to both the northward and southward migrations. Most of the effects of the winds stated are intensified when the wind is strong.

It has been observed that after a period of adverse or light winds, during which no migratory movement was noticed, a moderate wind in a direction favorable to the migration causes a marked migratory movement, especially if such a wind is general and not local. It thus seems evident that birds wait for a favorable wind to carry them on their migrations.

Changes of temperature, without doubt, affect the migratory movements of hawks, but, as has already been shown, a number of large flights have occurred in autumn on days when rises of temperature occurred near where the hawks started on their journeys. Moreover, flights of hawks often occur on cool days in spring, lower temperature usually accompanying west winds at that season of the year.

Water birds, particularly the Limicolæ, migrate in large numbers from the north in July, before the hottest period of the summer has passed. It is not surprising, therefore, to find causes affecting the time of migration of birds other than changes of temperature.

It is probable that many varieties of birds regularly make use of the wind as a physical agent in carrying them on their migratory journeys, the habit being well formed in the case of the Falconidæ.

Physical Laboratory, Columbia University,
New York.

NOTES AND LITERATURE.

ZOÖLOGY.

North American Deer. — *The Deer Family*,[1] by Theodore Roosevelt and others, is a popular account of the deer found in North America, written by men eminently fitted by experience and personal knowledge to deal with the subject from the double viewpoint of the naturalist and sportsman. The first half of the book is by Mr. Roosevelt, who furnishes the introductory chapter (pp. 1–27), and treats of the mule deer, or Rocky Mountain blacktail (pp. 28–64), the whitetail deer (pp. 65–97), the pronghorn antelope (pp. 98–130), and the wapiti, or round-horned elk (pp. 131–164); Mr. Van Dyke writes of the deer and elk of the Pacific coast (pp. 167–191), Mr. Elliot of the caribou (pp. 257–287), and Mr. Stone of the moose (pp. 288–325). Mr. Roosevelt, through his many years of ranch life on the Little Missouri and his numerous protracted hunting trips in the great game regions of the West, writes not only from abundant opportunity for observing the habits of the animals, but with the sympathy and intelligence of a keen naturalist as well as an ardent sportsman.

In the introductory chapter reference is made to the misapplication of names "by all peoples of European descent who have gone into strange lands," not only in reference to some of our deer and pronghorn, but to other game animals and birds. The deer of North America are grossly classified as forming six kinds: "The moose, caribou, wapiti, whitetail, and the two blacktails," minor differences being very properly disregarded. Their geographical ranges and leading characteristics are briefly stated, with some comment on the equipment required by the hunter of large game.

There is reference also to "the most striking and melancholy feature in connection with American big game, — the rapidity with

[1] **Roosevelt, Theodore; Van Dyke, T. S.; Elliot, D. G.; and Stone, A. J.** *The Deer Family*. New York, The Macmillan Company, 1902. 8vo, ix + 334 pp., 10 illustrations by Rungius, 7 maps by C. Hart Merriam, and numerous half-tone cuts of antlers of moose and caribou. American Sportsman's Library Series, edited by **Caspar Whitney.**

which it has vanished"; and, says Mr. Roosevelt, "if we are a sensible people, we will make it our business to see that the process of extinction is arrested. At the present moment the great herds of caribou are being butchered as in the past the great herds of bison and wapiti have been butchered. Every believer in manliness, and therefore manly sport, and every lover of nature, every man who appreciates the majesty and beauty of the wilderness and of wild life, should strike hands with the far-sighted men who wish to preserve our material resources, in the effort to keep our forests and our game beasts, game birds, and game fish — indeed, all the living creatures of prairie, and woodland, and seashore — from wanton destruction. . . . But this end can only be achieved by wise laws and by resolute enforcement of the laws."

The work is thoroughly non-technical in character, even to the omission of the scientific names of the species throughout most of the chapters, yet it loses nothing in scientific interest or value thereby. As a contribution to the natural history of the big game of North America its importance cannot easily be overestimated, there being here brought together more first-hand knowledge of the life histories of the species treated than has ever before been placed on record. Mr. Rungius's illustrations are effective and appropriate, while the numerous half-tone cuts of heads and antlers of moose and caribou are important and interesting features. The seven maps, by Dr. Merriam, showing the ranges of the deer, elk, and pronghorn in the year 1900, have a melancholy interest and great permanent value. That showing the present range of the elk is a sad commentary on the wasteful destruction of big game in North America. A hundred years ago this animal ranged from near the Atlantic seaboard westward to the Pacific coast, and from southern Canada into Mexico, forming, in some sections of the country, bands of thousands. Now its range is restricted to a narrow strip of country in the main Rocky Mountains, from Alberta to the northern border of New Mexico, with a few isolated areas of very small extent in California, Oregon, Arizona, Montana, North Dakota, and Minnesota.

The Deer Family is thus not only a book of special interest for the sportsman and the general reader, but an invaluable contribution to the natural history of the deer tribe in North America. It should also stimulate interest in the protection by all rational means of the waning remnants of the former great herds of these noble and attractive creatures.

J. A. A.

Upland Game Birds.[1]— This volume, by Edwyn Sandys and T. S. Van Dyke, is the second in the American Sportsman's Library Series, edited by Caspar Whitney, and, like the first, *The Deer Family*, by Roosevelt and others, shows the editor's good judgment in the selection of his authors for this noteworthy series of books. The scope of the work includes not only the turkey, grouse, partridges, and mourning dove, as would be expected, but also the cranes, woodcock, the upland and golden plovers, and introduced "foreign game," but not the snipe. Although written ostensibly for sportsmen by sportsmen, it has a much broader interest. Its attractive style, varied incident, and personal reminiscences must render it attractive to the general reader, and especially to those interested in the wild things of nature. The successful sportsman is necessarily a keen observer, and long experience in his craft renders him familiar with the ranges and life histories of his favorite objects of pursuit; but few have the literary gift to impart attractively to others the fund of information gained through such varied and extensive opportunities of observation. The authors of the present volume are well equipped for their task, as regards both experience and literary ability.

Mr. Van Dyke's portion of the work (pp. 377–417) relates exclusively to "The Quail and Grouse of the Pacific Coast," with which he shows himself especially familiar. The rest of the field (pp. 1–376) is covered by Mr. Sandys, whose several chapters contain much that is detailed and explicit regarding the habits and peculiarities of the game birds he treats, and in many ways admirably supplement the much that has been written by ornithologists. The spirit of the naturalist pervades the pages of *Upland Game Birds*, although they are amply enlivened by personal reminiscences that should prove especially attractive to the sportsmen; and the authors also neglect no opportunity to castigate the "game hog," and to urge more effective protection for game birds. Five of the nine very effective and pleasing illustrations are by Mr. L. A. Fuertes.

J. A. A.

Nestlings of Forest and Marsh,[2] by Irene Grosvenor Wheelock, contains accounts of the home life of about twenty birds, most of

[1] Sandys, Edwyn, and Van Dyke, T. S. *Upland Game Birds.* New York, The Macmillan Company, 1902. 8vo, ix + 429 pp., frontispiece and 8 full-page plates. American Sportsman's Library Series, edited by Caspar Whitney.

[2] Wheelock, Irene Grosvenor. *Nestlings of Forest and Marsh.* Chicago, A. C. McClurg & Co., 1902. 8vo, xvi + 257 pp., 22 pls., text-figs.

them common and familiar, *e.g.*, the oriole, robin, crow, brown thrasher, a few less well known, such as the long-billed marsh wren and the yellow-headed blackbird. By commendable energy and patience the author has obtained notes describing the selection of the nesting site, the search for materials for building, the care of the young, and their efforts, successful or tragic, to make a start in life. In her "Foreword" the author claims that her book is "as accurate as careful observation in the field can make it"; nor does anything in the book seem inconsistent with this claim. It is not, however, safe to accept all her conclusions from the facts recorded. She says further: "So far as reading human characteristics into animal life is concerned, can any one tell where the brute ends and the human begins? Many of the emotions of man's heart find their counterpart in the life of birds. That we do not perceive this proves only how dull is our sight." The most hazardous attempt to read bird minds is the account, on pp. 119 and 120, of a supposed successful attempt of chickadees to poison a young one which had been made a captive. The story is told in the best faith, but it is an excellent example of what Prof. Lloyd Morgan has felicitously termed "the inability to distinguish the observed fact from the observer's inference." It is curious that the author seems wholly ignorant of Professor Herrick's book, which has laid the foundations of that part of the study of birds which she has chosen for her field. An acquaintance with Professor Herrick's work would have saved her from assuming that a parent bird "seemed to know instinctively which one [of the nestlings] had been fed." The study of the marsh birds is the most interesting part of the book, but several of the other chapters contain bits of valuable information, *e.g.*, the account of the destruction by red-headed woodpeckers of the nests and young of cliff swallows. In an attempt to write brightly and entertainingly, the author too frequently sacrifices dignity, nor can her humor be said to be of a high order. The illustrations are, with a few exceptions, poor, though it should be said that this fact is partly due to the evident reluctance of both the author and the photographer to interfere with the home life of the birds under observation.

A New Genus of Nemerteans.[1] — An important paper by Miss Thompson describes the anatomy, histology, and relationships of a new heteronemertean, of especial interest because it apparently

[1] Thompson, Caroline B. Zygeupolia litoralis, a New Heteronemertean, *Proc. Acad. Nat. Sci. Philadelphia* (December, 1901), pp. 657–739. Pls. XL–XLIV, 1902.

forms a connecting link between two formerly well-differentiated families. The species *Zygeupolia litoralis* is not uncommon at Woods Hole, Mass., and because of its transparency would make an admirable form for class study wherever the living worms can be obtained. Most of the principal features of its anatomy can be demonstrated on the living worm under the low power of the microscope.

The general color of the body appears to be independent of sex and of sexual maturity, while that of the intestinal cæca depends upon the amount and character of the food therein. In external appearance the species so closely resembles *Micrura cæca*, with which it is sometimes associated, in size, shape, and color, "that the two can scarcely be distinguished without a hand lens which reveals the absence of lateral slits in the former and their presence in the latter."

In the excellent and detailed description of the different organ systems the following points are of especial importance: The proboscis has no retractor muscle, its posterior end lying entirely free in the rhynchocœl, exactly as has been described for *Cerebratulus lacteus*.[1] The musculature of the proboscis consists of two principal layers arranged as in many of the Lineidæ, and there are also more or less distinct muscular crosses so characteristic of this family. A strong layer of circular muscles surrounds the posterior end of the stomach, but ends abruptly at the beginning of the intestinal region. This forms a definite inner layer of circular muscles which the author looks upon as homologous with the inner circular layer of Carinella, and which is so highly developed in exactly the same region in Carinoma. Her views are well supported by diagrams and figures, and seem to be conclusive. A similar, but less highly developed, muscular layer has been described for Micrura.

The œsophagus exhibits two well-marked regions differing greatly in histological features, the posterior œsophagal cavity, or stomach, being lined with cells which resemble far more closely those found in the intestine than those of the œsophagus proper. This suggests that the anterior œsophagal cavity only may have arisen from the ectoderm, while both stomach and intestine are derivatives of the entoderm.

The caudal cirrus, or caudicle, has been studied in detail, and the statements of various observers who have described this organ erroneously are corrected. The posterior opening of the intestine lies

[1] Coe. *Trans. Connecticut Acad.*, vol. ix (1895), p. 488.

above the base of the cirrus and not, as has sometimes been described, beneath it. In section the caudal cirrus shows the outer epithelium, a thin circular and comparatively strong longitudinal muscular layer, and a zone of mesenchyme cells surrounding a large central blood space. The two lateral nerves are here situated in the outer epithelium, the outer longitudinal muscular layer and cutis being absent. Neither do the gonads, intestine, nor proboscis sheath continue back into this organ. This description agrees closely with the characters given by Punnett for the caudal cirrus of *Micrella rufra*,[1] except that he finds only rudimentary blood vessels.

The distribution of cutis glands has been very fully studied. A pair of neurochord cells was found in the ventral ganglia. A longitudinal groove on each lateral margin of the body just anterior to the intestinal region is looked upon as a sense organ which may be homologous with the lateral sense organs recently described by Punnett for Micrella,[2] where they are situated just back of the excretory pore, as are the well-known sense organs in Carinella.

Blood lacunæ were not found anterior to the brain; lateral blood vessels are united at intervals below the œsophagus. A large lacuna without definite walls passes into the caudal cirrus. Parasitic gregarines were found in the intestinal epithelium and in the ova. Infected eggs grew to several times their normal size.

The evidence that the genus Zygeupolia should be placed among the Lineidæ seems conclusive, the only feature distinguishing it from other members of the family being the absence of cephalic furrows. It is rightly regarded as the most primitive or aberrant member of that family which has yet been described. With Punnett's new genus Micrella there is certainly a close relationship, and both forms serve to bridge over the gap between the Eupolidæ and the Lineidæ. In many points of anatomy the two genera are very similar, and while in Zygeupolia the cephalic furrows are wanting, yet an approach to this condition is found in Micrella, where the furrows reach only half way to the brain. Punnett's new genus Oxypolia likewise forms a connecting link in the series, although this clearly belongs to the Eupolidæ, being more closely related to Valencinia.

W. R. C.

[1] Punnett. *Quart. Journ. Micr. Sci.*, vol. xliv (1901), p. 553.

[2] Punnett. *Loc. cit.*, p. 551.

BOTANY.

Elementary Plant Physiology.[1] — This new and completely revised edition of the same author's earlier book, *Experimental Plant Physiology*, will without doubt be welcomed by the teacher. The experiments chosen are almost all of the simpler kind, being qualitative rather than quantitative, for which reason they will especially recommend themselves for use in elementary courses.

In the introductory chapter is given a series of selected courses which will serve as useful suggestions to the inexperienced or hurried teacher. At the same time the number of experiments described is sufficiently large to allow of independent choice, so that any course selected from the book may have a certain elasticity — a point of no little importance.

In starting out with the consideration of growth the author has undoubtedly chosen that phase of plant physiology which appeals most strongly to the average student, a fact which warrants the choice, when it is remembered that the object is to introduce the beginner to the subject. The chapters on the exchange of liquids and gases and on the general subject of nutrition are full and seem entirely adequate for the scope of the book. The wisdom of leaving the consideration of the effects of stimulation and correlation (the various trophic phenomena) to the last, in a place removed from the related topic of growth, might be questioned if the evident intention of the author were not taken into consideration. It is clearly his object to impress most strongly upon the student the phenomena connected with general and, on the whole, less complicated problems of plant physiology and to touch lightly upon the more intricate ones connected with correlations of growth. There are many reasons justifying such a treatment in an elementary course, particularly in a course which presumably would not be accompanied by many explanatory lectures or by much reading.

The text is terse and clear, the typography and form of the book excellent, both the author and publisher are to be congratulated on having produced a very acceptable and practically useful laboratory guide.

H. M. R.

Notes. — A new botanical publication, the *Recueil de l'Institut Botanique* (*Université de Bruxelles*), has been launched by Professor

[1] MacDougal, D. T. *Elementary Plant Physiology*. New York. Longmans, Green & Co., 1902. 8vo, xi + 38 pp., 108 figs.

Errera, after the plan of the "Contributions" from various other scientific establishments and laboratories. It is to contain original contributions and reprints of studies from the laboratory that have been published elsewhere. Rather curiously, it begins with Vol. V, but the first four volumes of the series are definitely planned and are promised for the early future. In form and style the *Recueil* is excellent. As would be expected from Professor Errera's own studies, the contents of this volume, as well as of the other four that are promised, are largely physiological or cytological.

Under the title *The New Phytologist*, a new British journal, edited by Professor Tansley, has made its appearance in London. Among other things, the first number contains "A Revision of the Classification of the Green Algae," by Blackman and Tansley.

A new botanical journal, entitled *Magyar Botanikai Lapok* (*Ungarische Botanische Blätter*), is published at Budapest, beginning with January of this year.

The index to new species and varieties published in Engler's *Botanische Jahrbücher*, Vols. XXVI – XXX, occupies 45 double-column pages of the concluding number of the last-named volume.

The April *Bulletin of the Torrey Botanical Club* contains the following papers: Salmon, "Supplementary Notes on the Erysiphaceæ"; Cook, "Development of the Embryo Sac and Embryo of *Castalia odorata* and *Nymphæa advena*"; Piper, "New and Noteworthy Northwestern Plants, VI"; Arthur, "New Species of Uredineæ, II"; and Rydberg, "Studies on the Rocky Mountain Flora, VIII."

The *Ottawa Naturalist* for March contains papers on the botany of the West and Northwest by Macoun and Greene.

No. 2 of the *Biltmore Botanical Studies*, dated April 30, 1902, contains the following papers: Beadle, "New Species of Thorns from the Southeastern States, II"; Boynton, "Studies in the Genus Amorpha"; Boynton, "Two New Southern Species of Coreopsis"; Boynton, "Notes from a Collector's Field Book"; Harbison, "A Sketch of the Sand Mountain Flora"; Harbison, "New or Little-Known Species of Trillium, II"; Beadle, "Studies in Philadelphus"; Beadle, "Two Drupaceous Trees [*Prunus australis* and *P. mitis*] from Alabama."

The January number of the *Bulletin of the Wisconsin Natural History Society* contains the following botanical articles: Brunchen, "Studies in Plant Distribution"; Graenicher, "Flowers adapted

to Flesh-Flies"; Bennett, "Additions to the Flora of Milwaukee County"; and Brown and Fernekes, "Contribution toward a List of Milwaukee County Fungi."

A number of illustrations of botanical interest are contained in the recently published seventh *Report of the Forest, Fish and Game Commission of New York.*

The Engelmann Botanical Club of St. Louis has issued an excellent bulletin on tree planting, giving practical instruction as to what not to do, as well as what to do, in attempting to beautify a city by the growth of trees.

Dr. Urbina, of the *Museo Nacional* of Mexico, has distributed from the *Anales* of that institution a botanical study of the various Zapotes of Mexico.

In a separate recently issued from the *Transactions of the Royal Society of Canada*, Dr. Fletcher writes on the value of nature study in education.

The principles of generic nomenclature are discussed by Mr. Shear in the *Botanical Gazette* for March.

The leaf forms of Liriodendron are discussed and figured by Berry in *Torreya* for March.

An account of the acaulescent violets of central New York, by H. D. House, is published in *Torreya* for May.

A new species of Viola, *V. angellæ*, from New Jersey, is described by Polland in *Torreya* for February.

A yellow-fruited form of *Ilex myrtifolia* is noted by R. M. Harper in *Torreya* for March.

Ailanthus grandis, a new Indian species, is described and figured by Prain in *The Indian Forester* for April; he also gives comparative notes on the other species of the genus and their distribution.

The morphology and anatomy of *Azorella Selago* are treated by Charlotte Ternetz in Heft 1 of Abtheilung I of the *Botanische Zeitung* for this year.

Continuing his studies of Ochnaceæ, Van Tieghem, in the April *Journal de Botanique*, separates from the old genus Ochna the new genera Ochnella, Porochna, and Discladium, giving differential keys for the genera of the tribe Ochneæ as so constituted.

A new Zauschneria, *Z. arizonica*, is described by Dr. Davidson in the *Bulletin of the Southern California Academy of Sciences* for January,—the initial number of this publication.

Dr. Weber, who in former years studied Opuntias with Engelmann, has issued separates, from the *Bulletin de la Société Nationale d'Acclimatation de France*, of an article on the species (*O. leucotricha*) which furnishes the prized "Duraznillo," or peach prickly pear of the high table-lands of Mexico, and its immediate relatives.

An interesting account of the hallucinations caused by taking an infusion of *Anhalonium lewinii* is published by Havelock Ellis in the *Popular Science Monthly* for May.

A photogram of *Echinocactus texensis* is published in the *Monatsschrift für Kakteenkunde* for April 15.

In No. 7 of the current volume of botanical *Proceedings of the California Academy of Sciences*, Miss Eastwood gives a key to fifty-seven species and varieties of Ribes recognized as occurring on the Pacific coast, and describes nine species as new.

Matsumura publishes a list of the wild and cultivated Leguminosæ of Japan, Loochoo, and Formosa, in the Tokyo *Botanical Magazine* of March 20.

M. Theuriet, an amateur of roses, published an illustrated classified list of the 6781 species and varieties cultivated at l'Haÿ, France.

Blanchard has a note on the Vermont chokeberries in *Rhodora* for March.

In *Pharmaceutical Archives* for April, Mr. Denniston publishes a paper on the general and bark characters of *Viburnum ellipticum*.

A large and fully illustrated paper on the comparative embryology of the Rubiaceæ, by F. E. Lloyd, constitutes Vol. VIII, No. 1, of the *Memoirs of the Torrey Botanical Club*.

An account of *Primula parryi*, with an excellent half-tone illustration, is published by Knowlton in *The Plant World* for February.

Scrophularia glabrata, from Arizona, is described and figured by Davidson in the March *Bulletin of the Southern California Academy of Sciences*.

The seeding of *Plantago fastigiata* is the subject of a paper by Griffiths in the *Bulletin of the Torrey Club* for March.

Peperomia davisii, from St. Kitts, is described by Britton in *Torreya* for March.

A cockscomb fasciation of the pineapple is noted by Harshberger in the concluding part for 1901 of the *Proceedings of the Academy of Natural Sciences of Philadelphia*.

In the *Botanical Gazette* for April, DONNELLIA C. B. Clarke is proposed for the reception of *Callisia grandiflora* Donnell Smith. The new genus constitutes one of the many segregates of Tradescantia.

An interesting account of the harvesting, curing, and cleaning of the seed of *Poa pratensis*, the standard lawn grass of the United States, forms *Bulletin No. 19* of the Bureau of Plant Industry of the Department of Agriculture, by Pieters and Brown.

E. D. Merrill publishes some notes on Sporobolus in *Rhodora* for March.

A study of the Zamias of Florida, by Wieland, is published in *The American Journal of Science* for May.

The North American genera of Aspidieæ are discussed by Underwood in the *Bulletin of the Torrey Botanical Club* for March. A key is given to the genera.

The evergreen ferns of New England are considered by Davenport in *Rhodora* for March.

In *The Fern Bulletin* for April Mr. Maxon proposes the restoration of Liebman's name *Asplenium resiliens* for what is commonly known as *A. parvulum*.

In an article on "The Logfern" (*Dryopteris Cristata Clintoniana*), Mr. William Palmer gives a key to the cristata and Goldieana groups of that genus, in *The Fern Bulletin* for April.

The mechanical expulsion of the brood bodies of several species of Lycopodium is noted by Lloyd in *Torreya* for February.

Several species of Lycopodium, and the propulsion of the gemmæ of some species, are considered by Mr. Leavitt in *Rhodora* for March.

The tenth of Mr. Alvah Eaton's papers on the genus Equisetum in North America, in *The Fern Bulletin* for April, deals with the varieties of *E. litorale*.

A monograph of the Lejeuneæ of the United States and Canada, by Evans, constitutes Vol. VIII, No. 2, of the *Memoirs of the Torrey Botanical Club*.

Two new western mosses are described and figured by R. S. Williams in the February *Bulletin of the Torrey Club*.

PETROGRAPHY.

Weinschenk's "Die Gesteinsbildenden Mineralien"[1] affords the most satisfactory introduction to petrography that has yet appeared. Its first 47 pages are devoted to the physical and chemical methods employed in the separation of rock constituents and in the determination of the character of isolated mineral particles. The remainder of the volume describes briefly the principal rock-forming minerals as they appear under the microscope. In spite of the brevity of the treatment necessitated by the small size of the book nearly all the essential facts relating to the characteristics of the individual minerals are to be found in its pages. The reader is supposed to be already acquainted with the general principles of optics, so no space is devoted to this subject.

The special feature of the book is the collection of 18 plates, bound in two brochures and enclosed in a pocket from which they may be removed for ready reference. They contain summaries of the physical, chemical, optical and crystallographic characters of the minerals discussed in the text; a list of minerals classified according to their color, in thin sections, and their crystallographic habits; lists of those exhibiting optical anomalies, twinning structures, distinct cleavages, and of those whose powder reacts alkaline; and lists in which the minerals are arranged according to their magnetic strength, their solubilities, their fusibility, their density, their refracting indices, the strength of their double refraction, and their optical character. These tables are so well arranged and they embody such a mass of information in small compass that they will prove not only useful to younger students but also extremely valuable to those of maturer experience.

So far as the writer knows, the present volume is the only modern elementary treatise on the microscopical characters of rock-forming minerals that can safely be recommended to beginners in the study.

W. S. B.

[1] Weinschenk, Ernst. *Die Gesteinsbildenden Mineralien.* Freiburg, Herdersche Verlagshandlung, 1901. 146 pp., 100 figs., 18 tables.

(*No. 428 was mailed August 19.*)

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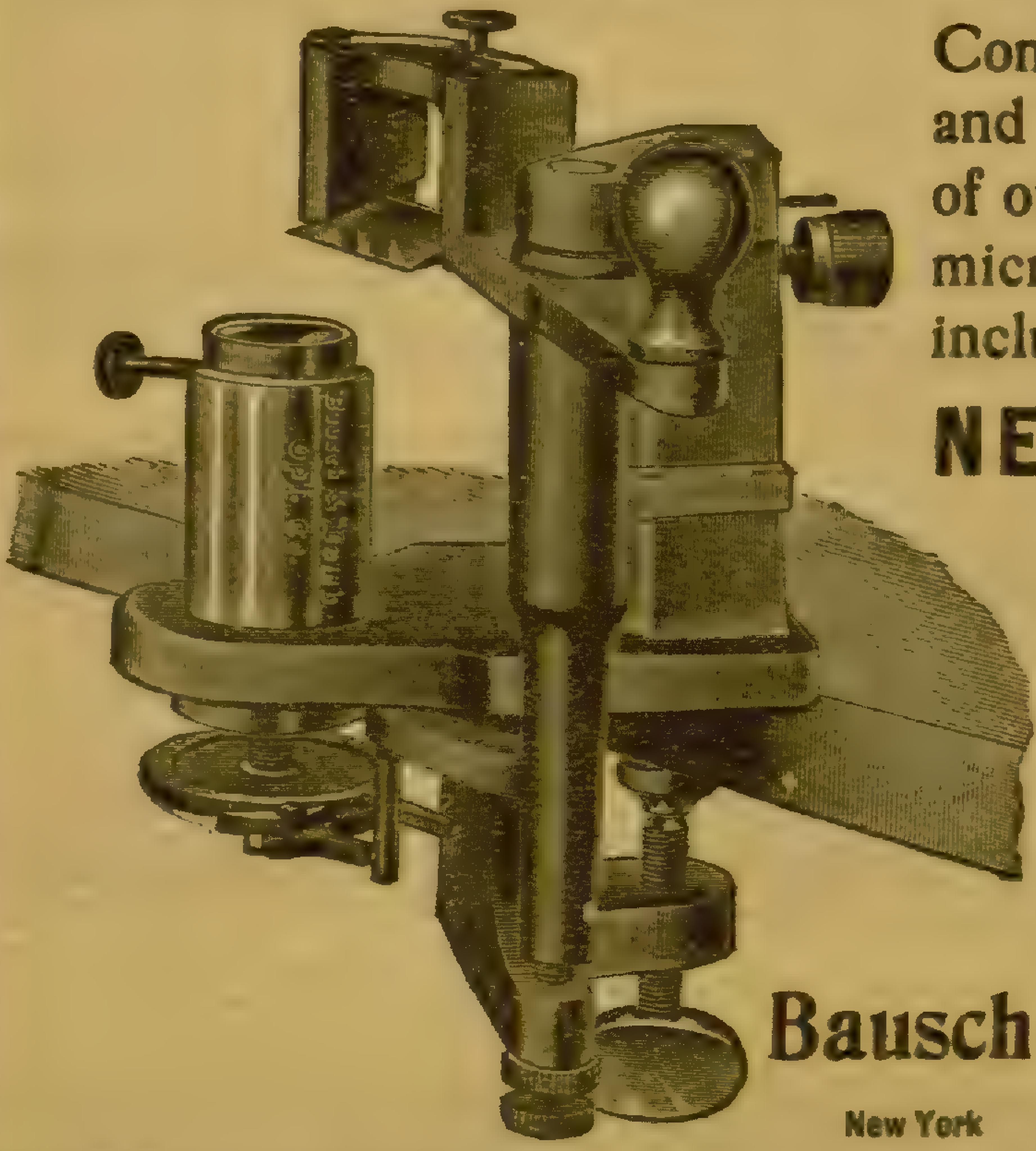

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THE AMERICAN NATURALIST

A MONTHLY JOURNAL
DEVOTED TO THE NATURAL SCIENCES
IN THEIR WIDEST SENSE

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THE

AMERICAN NATURALIST

Vol. XXXVI. *October, 1902.* No. 430.

HISTORICAL EVIDENCE AS TO THE ORIGIN OF THE PAIRED LIMBS OF VERTEBRATES.

BASHFORD DEAN.

Whatever be the results of embryologists, the real test of the problem of the mode of origin of the paired limbs of vertebrates belongs obviously to paleontology. For if the paired limbs, as most morphologists believe, arose as highly specialized lappets of a continuous lateral skin fold, it is quite evident that sooner or later these conditions will be demonstrated convincingly among the earlier fossil fishes. In point of fact, the paleontological evidence bearing upon this matter is of such great value, even at the present time, that we can justly regret that it has received scanty attention at the hands of embryologists. It is indeed so imperfectly noticed in the recent voluminous papers which bear upon the general problem of limb origin that I have been led to the following comments.

I. The Weight of Evidence.

If we accept the general rule that earlier forms are of greater value for purposes of determining primitive characters than are later ones, and if we admit that a study of many genera and

many species is of greater value than an examination of few specimens of few species, we must, I believe, conclude that the doctrine of the origin of the paired limbs from lateral dermal folds rests upon strong foundations. Reducing to simplest terms our knowledge of the earliest sharks or shark-like fishes, among which the ancestral jaw-bearing vertebrates are reasonably sought, we find that of forty odd species, representing fifteen genera (Paleozoic), whose fin characters are known, all but those of a single genus, and possibly a second, are distinctly in favor of the lateral-fold theory. And the exceptions to the rule are the most recent forms and in important structural regards the least primitive.

More concretely, such genera as the Upper Silurian and Lower Devonian Parexus (two species), Climatius (eight species), Diplacanthus (five species) (=family Diplacanthidæ), Cheiracanthus (three species) (Acanthodidæ), and the long-enduring Acanthodes (twelve species) (Lower Devonian to Permian); as the Upper Carboniferous Acanthodopsis (but we may put the last aside, since its fin structures are not as well known as in the neighboring forms); as the Permian Protacanthodes and Traquairia, — all of these ancient sharks have their paired limbs in the form of distinct longitudinal skin folds, and these paired fins, furthermore, are essentially similar to the unpaired ones. This conclusion is based upon numerous and well-preserved specimens. The next ancient sharks whose fin structures are described are the (now accepted as) Upper Devonian cladoselachids (about two genera and six species). These have the paired fins extended along the body, their hinder web narrowing gradually and merging with the body wall, showing no trace of a lobate fin base projecting from the body. Here, too, the paired fins closely resemble the unpaired fins. Structural details in these forms are known from a score or more of well-preserved specimens. A kindred Upper Devonian shark is Ctenacanthus, whose fin structures have hitherto been unknown; but an interesting specimen of this form, showing pectoral fins and spine *in situ*, has now been discovered, and it shows convincingly that this shark had a fin-fold type of fin. Its radials pass to the margin of the fin, as in Cladoselache,

each with a corresponding basal; unlike cladoselachids, there are no intercalated rays. Next ancient is Traquair's specimen of Cladodus (Lower Carboniferous) (*cf.* Fig. 1), whose pectoral gives evidence of a line of basal plates extending backward like

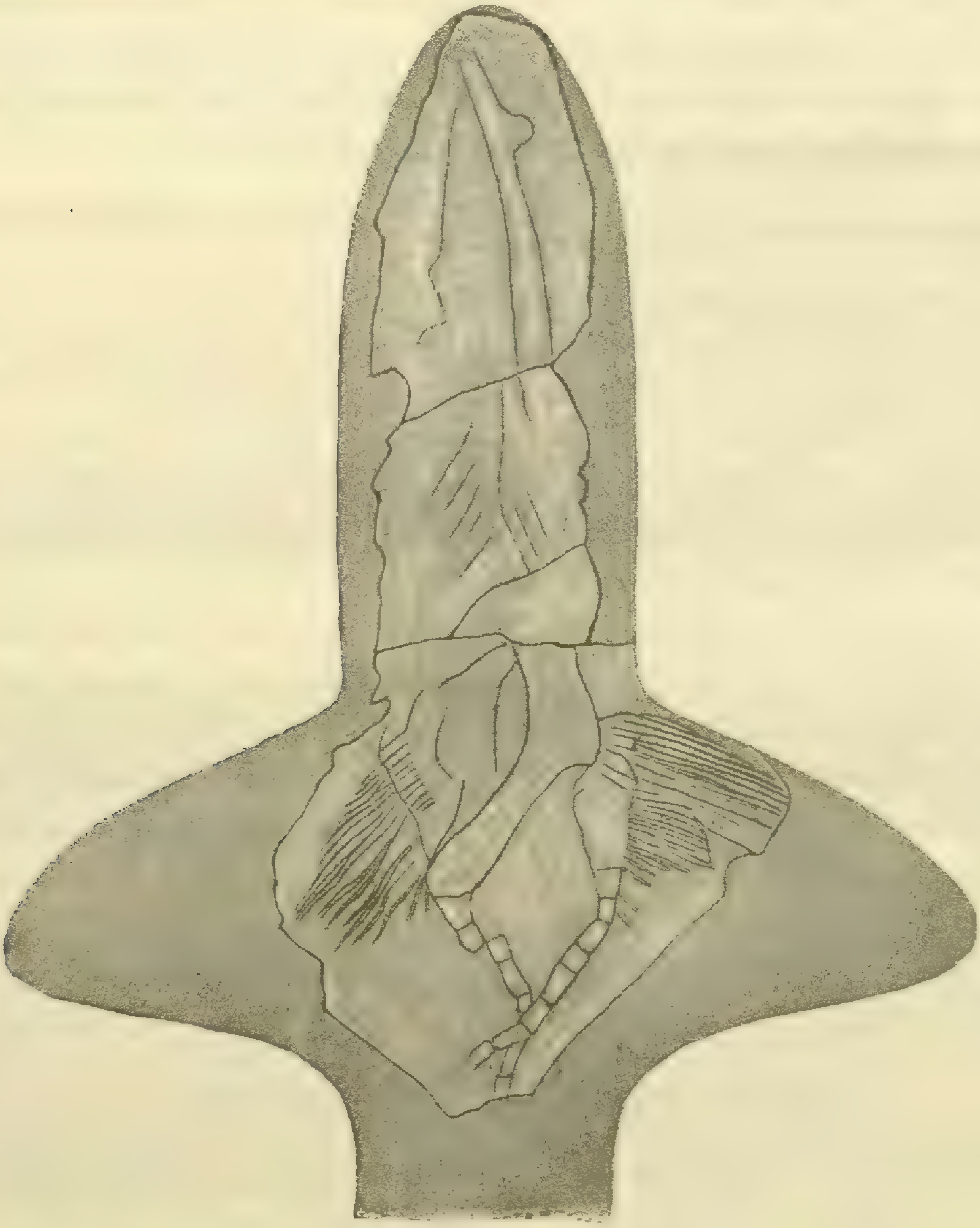

FIG. 1.—The Paleozoic shark *Cladodus neilsoni* Traquair. The fossil is shown surrounded by the outline of a specimen of Cladoselache of similar size,—indicating that the fins of Cladodus were of larger size than the present fossil suggests.

a rayless axis of an "archipterygial" fin. This specimen has been taken in evidence of the non-primitive nature of the fin-fold type of limb (*vide infra*). Last of the ancient forms are the Permian symmoriids and xenacanthids. Of these Symmorium, judging from the single fragmentary pectoral described

by Cope, is similar to cladoselachids, but remarkable in that its hindmost rays apparently coalesce at their bases so as to form a stout supporting plate. There is no evidence, however, that this projected from the body wall, nor have we any knowledge of pelvic or unpaired fins. In xenacanthids, on the other hand, many and well-preserved specimens (of two or three species) show a biserial archipterygium in the pectoral fin, and this condition has been the main paleontological stay of those who oppose the fin-fold hypothesis. They lay no emphasis, however, on the late appearance of this form (for there is no evidence forthcoming that the Coal Measure "Xenacanthus" had fins like the Permian form), or on the facts that its ventral fin is *not* a biserial archipterygium but resembles closely the unpaired fins immediately behind it, and that this form has already developed a mixipterygium, and has specialized an amphistylic attachment of jaw to skull, and that it has largely lost its integumental defenses.

Balancing the matter fairly, I think that we must conclude that the weight of the evidence of Paleozoic sharks falls emphatically on the side of the longitudinal fin-fold hypothesis. Indeed the only way, as far as I can see, in which this evidence can be denied is by a frank rejection of the well-accepted view as to the primitive nature of the earliest elasmobranchs (Proselachii).

II. The Fin-Fold Character of the Earliest Forms, Acanthodians and Cladoselachids.

The dermal-fold nature of the paired fins of the acanthodians requires little comment. Excepting in a brief note of Dr. Fritsch,[1] no attempt has ever been made to explain them in accordance with the theory of Gegenbaur; that is, that their origin is due to outgrowth of elements belonging to serially homologous gill bars. Continuous fin folds they certainly are,

[1] *Fauna d. Gaskohle Formations Böhmens* (1893, p. 71), in which the spine is regarded as the archipterygium. Dr. Jaekel homologizes shoulder girdle to gill arch, but does not consider the relations of the fins themselves. *Verhandl. Deutschen Zool. Gesell.* (1899), pp. 256–258.

whether or not we accept the origin of their supporting elements as equivalent to the coalesced radial supports of a more typical shark-like fin. On the other hand, the paired fins of the cladoselachids are distinctly shark-like, although in pattern unlike those of later selachians. They are remarkable in that they are built on the plan of balancing organs; *i.e.*, the fin was attached keel-fashion, along the side of the body, and probably functioned by means of ventrad and dorsad movements (undulatory at fin margin ?). And the blade of the fin could not be rotated (twisted) sideways. This is attested structurally by (1) its graded series of radials, — larger, most numerous, and most crowded in the anterior region; (2) by the absence of a metapterygial lobe, and in the continuation of the fin web hindward along the margin of the body; physiologically (3) by its close analogy with the dorsal and anal of such a form as Mola, in which we know that this undulatory movement has been specialized. That the paired fins of Cladoselache, moreover, cannot be interpreted as "due to bottom living" on the plan, *e.g.*, of Rhina, becomes clear when we consider that the radial cartilages are unjointed throughout their length, that the ventral and pectoral fins are not drawn together in a ray-like way, and that the fins, in spite of their remarkable character, are *as small in proportion to the size of the body as those of modern selachians* (Pristiurus, Scyllium), *which are known to be free swimming*. (*Cf. Natural Science*, Vol. VIII (1896), pp. 250–252, and *Anat. Anzeiger*, Bd. XI, pp. 673–679. *Vide* also *infra*.)

III. The Evidence of Paleontology as to the Development of the Unpaired Fins.

In recent work tending to support the hypothesis of Gegenbaur no reference is made to the mode of origin of the unpaired fins. This, we must grant, would have an important bearing upon the problem of the extremities if evidence existed to show that in a late stage in the evolution of the unpaired fins an archipterygium arose, like that of the paired fins. As a matter of fact, paleontology demonstrates that such a condition

is represented in the case of the ancient ganoids (crossopterygians); for in certain Devonian forms (*cf.* also Mesozoic genera) the dorsal fins show clearly concrescence of radial and basal elements in a way which parallels strikingly the biserial archipterygium (of the paired fins).[1] This condition, although well known to the paleontologist, appears to have escaped the notice of the adherents to the Gegenbaurian school. It is perfectly evident that if the biserial archipterygium arises in the unpaired fin from the concrescence of lateral fold-like supporting elements, the similar structure in the paired fins must have arisen in a similar way, or, to say the least, the burden of disproof lies with those who believe that such closely similar structures arose by diametrically opposite processes.

IV. CONCLUSION.

The evidence of Paleozoic sharks, then, is most distinctly in favor of the Thacher-Balfour teachings. The oldest forms, acanthodians and cladoselachids, represented by the best-preserved fossils present lateral-fold fins. Moreover, there is evidence that as the series advances from the Lower Devonian, the structures of the biserial archipterygium are gradually acquired. The Carboniferous *Cladodus neilsoni*, Fig. 1, of Traquair shows for the first time a definite segmentation of the supporting elements of the base of the pectoral fin.[2] Then in the Permian Symmorium Cope, the fin bases not only are formed, but show apparent fusion in the metapterygial region, and even perhaps an extension from the body wall of the metapterygial terminal, a condition which would be best correlated with a change of function in the fin. And finally, in the xenacanthids, whose structures are known only in this later horizon, the pectoral fin acquires a biserial archipterygium. The conditions, however, of *Cladodus neilsoni* and of Symmorium

[1] *Cf.* also the anals of Xenacanthus.

[2] Judging from the size of the shark and the character of the radials, the pectoral fin was probably larger, and there is thus ground to believe that the posterior radials of the fin have been lost. This is better understood by reference to the accompanying Fig. 1, where the Scottish specimen is shown overlaid with an outline of Cladoselache of similar size.

are still doubtful, the present knowledge of them having been based upon single, imperfectly preserved, and fragmentary specimens. The conditions in Cladoselache, on the other hand, are known from upward of thirty specimens, some of which are admirably preserved.[1] In conclusion, if the Gegenbaurian adherents are to contest the sum and substance of the paleontological evidence, they have, it seems to me, the difficult task of demonstrating (1) that acanthodians, the most extensive group of Paleozoic sharks, do not possess pleuropterygia ; (2) that Cladoselache, in spite of its earlier occurrence and peculiar structures, is not as archaic a type of shark as Xenacanthus ; and (3) that the "archipterygium" formed in the unpaired fins as the terminal member of a series whose original structures were of fin-fold character, is formed in exactly the opposite way from the archipterygium in the paired fin. Until these contradictions have been disposed of, no evidence based upon recent forms can, I believe, attack the main trenches of the lateral-fold theory.

Postscriptum. — Objections which have been urged to the foregoing conclusions.

As far as I am aware, no objections have been raised to the conclusion that the paired fins of the acanthodians represent definite lateral dermal folds, whatever may be regarded as the homologues of the supporting elements of these fins. (Thus Fritsch endeavors to find in the pulp canals of the anterior fin spines rudiments of an entire biserial archipterygium (*Fauna d. Gaskohle Formations Böhmens*, Bd. III, p. 71). (As a corollary to this suggestion, I take it, the fin spines of *all* acanthodian fins are equivalent to archipterygia, since the spines are similar in structure in all fins !) Cladoselache, however, has been subjected to adverse criticism by several advocates of Gegenbaur's hypothesis. Professor Jaekel, the first of these critics, is the only one who appears to have had the opportunity of examining actual specimens of this form, for during his visit to

[1] Sections of the muscle plates have been found to show transverse striæ in the fossilized muscle cells. Their description will shortly be published.

New York he inspected some of the material obtained by Professor Newberry for the museum of Columbia University. He regarded "Cladodus" as a shark which had become highly specialized and adapted to bottom living. Against this view it is merely necessary to note that Cladoselache possessed dorsal fins, one of which was situated well forward on the trunk region, its anterior rim lying above the pectoral fin, a condition entirely unknown in any depressed type; that the caudal fin was of a peculiar form, extreme in its heterocercy, and provided on either side with broad, stout lateral flanges closely comparable to those of such swift-swimming forms as Isurus, or even scombroid fishes. It is evident that none of these characters can be associated with a bottom-living form such, for example, as Rhina. Moreover, *if Cladoselache were a bottom-living form, its fins would obviously have been larger in proportion to the size of the animal than those of recent sharks.* In this connection, however, it is only just to Dr. Jaekel to state that at the time of his visit to Columbia University none of the best material of this form had yet been obtained, — that the caudal and dorsal fins, for example, were not known.

A second writer, Professor Semon, in one of his studies on Ceratodus (*Forschungsreisen*, Bd. I (1898), pp. 105–106), subscribes to a page of general denial as to the primitive nature of Cladoselache. As he does not, however, refer to the detailed literature upon this form, quoting only from a single and semi-popular article, and in view of other omissions, I am inclined to believe that his criticism is inadequate. Thus I note that he is unaware that the horizon of Cladoselache is now conceded (*cf.* Orton and others) to be Upper Devonian instead of Lower Carboniferous, and that he puts this form in the Coal Measures side by side with xenacanthids, whose structural characters are known only from the Permian; also that he states that *dipnoans* (he does not mean by "dipnoans," I take it, the very problematical arthrodires, since these are naturally included in the term "placoderm," which he specifically mentions) *and crossopterygians were already present in Silurian times,*— a statement I can only account for on the basis either that he has collected data which, when published, will throw light upon this empty page of the geological

record, or that by Silurian he means Devonian, an age in which, by the way, we must admit that Cladoselache occurs. He surely cannot refer in the above terms to the minute fragments of Ostracophores of Oesel, which were once, about a decade ago, referred to as ganoidean and dipnoan.

And most recently Dr. Braus[1] has considered in a special paper the later discoveries in fin structures in fossil selachians, and has even concluded that "through paleontology the theory of Gegenbaur has been given new life." Braus, however, makes no reference in this connection to the archipterygial characters of unpaired fins, nor yet to acanthodians, and furthermore, he treats all extinct forms without reference to their different geological horizons. The pectoral fin of Cladoselache he regards as essentially similar to that of Chlamydoselachus, believing that its metapterygial region has been obscured by the overlying body wall during the process of fossilization, and that the fin in reality possessed a lobate base which projected from the body wall, as in the recent shark. He accordingly must believe that the continuous posterior dermal margin of the fin in the fossils, as several writers have figured it,[2] is not a just one. I think, however, that I am justified in stating that this reactionary view finds no support in any known[3] specimen of this form. And I may further add that the line which continues the web of the lappet-shaped fin along the side of the body, which Braus is skeptical about, and which is hostile to the Gegenbaurian theory, is preserved in faultless condition in as many as a dozen specimens which are now under my hands. Braus further believes that the ventral fin of Cladoselache shows a trace of a distinct metapterygium (as of Chlamydoselachus), inasmuch as radials occur in the hinder portion of the fin web,

[1] *Verhandlungen d. Phys.-Med. Gesellsch. zu Würzburg* (N.F.), Bd. xxxiv (1901), pp. 177–192; *cf.* also *Zool. Forschungsreisen.* Bd. i (1901), Lieferung III, pp. 197, 266, 268.

[2] The fin margin has thus been figured — rounding in along the body wall — undissentingly by at least four authors. Braus does not consider this important feature of the fin, which I am sure he would have felt bound to do had he examined actual specimens.

[3] I speak confidently, since I have good reason to believe that all cladoselachids have hitherto been obtained through three collectors in Ohio, whose output I have had the opportunity of examining.

a conclusion to which I do not understand the *sequitur*. The absence of mixipterygium in cladoselachids (as well as in acanthodians, in fact the whole matter of the acanthodians) he does not consider in this connection.

Braus, in summary, teaches that paleontological discoveries lead to the "overwhelming conclusion" that the recent shark fin has acquired its typical form of skeleton through a process of reduction wherein the original terminal and post-terminal axial portions have become lost, while the pre-axial region has developed and with it its basal plates. The reviewer, however, must confess that he finds it rather difficult to determine exactly how Braus has obtained these paleontological results, unless by deriving the Devonian forms from the Permian ones, — which, in view of the many remarkable structural characters of Cladoselache (which Braus also, by the way, does not consider), appears as unconvincing as a process which derives the Miocene Protohippus from the Pliocene horse.

RECENT INVESTIGATIONS UPON THE EMBRYO SAC OF ANGIOSPERMS.

DOUGLAS HOUGHTON CAMPBELL.

THE development of the embryo sac of the angiosperms has engaged the attention of many botanists from Hofmeister on, and the homologies of its parts have been widely discussed. All of the earlier researches seemed to indicate an extraordinary uniformity in the structures of the embryo sac, very few deviations from the type being noted, and the importance of these variations being frequently ignored.

With the improved histological methods developed in recent years there has been a renewed interest in the subject. The important paper by Treub on Casuarina[1] called attention to several striking deviations from the ordinary angiospermous type. This paper was followed by a long series of investigations by many botanists both at home and abroad, which have extended materially our knowledge both of the morphology and physiology of the embryo sac.

The uniform results of the earlier investigations may be explained, in part at least, by the selection of the more specialized forms for study. These would naturally conform, for the most part, to the structure characteristic of the embryo sac of the typical angiosperms. The more generalized and presumably more primitive forms were neglected, and the significance of such important variations as the largely increased number of antipodal cells in many grasses was usually overlooked. So great, indeed, was the uniformity assumed to be, that all efforts to explain the origin of the angiosperms from lower forms was considered well-nigh hopeless.

The studies of the last dozen years have shown that there is much more deviation from the type than was supposed to be the

[1] Sur les Casuarinées et leur place dans le système naturel, *Annales du Jardin Botanique de Buitenzorg*, tome x, pp. 143–231. Leyden, 1891.

case, and these have encouraged further researches upon the simpler types of angiosperms. Some of these have yielded interesting results, and already give some hints of the possible origin of the structures of the angiospermous embryo sac.

While it cannot be said that this very important point is likely to be explained satisfactorily in the near future, nevertheless it can be said that not unimportant advances have been made, and the purpose of this sketch is to bring together the most noteworthy results of these recent investigations, and to indicate their bearing upon the question of the origin of the angiosperms.

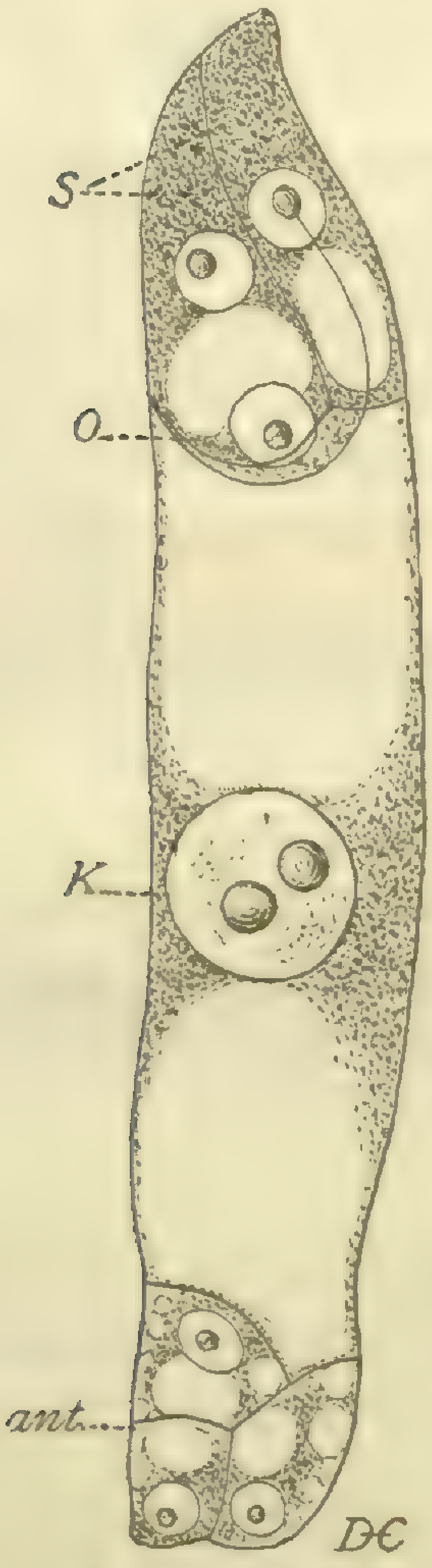

FIG. 1.—Embryo sac of *Monotropa uniflora*. At the micropylar end is the egg apparatus, consisting of the egg, *o*, and the two synergidæ, *s*; at the chalazal end, the three antipodals, *ant.*; the endosperm nucleus, *k*, still shows the two nucleoli of the polar nuclei of which it is formed.

In the great majority of investigated angiosperms the embryo sac, as is well known, exhibits extraordinary uniformity in its structure. In most instances the embryo sac arises from a subepidermal cell (Fig. 2 A), which may either develop at once into the embryo sac, or, as is more commonly the case, it divides into several cells, one of which becomes the embryo sac.

With the first division of the nucleus of the young embryo sac, the polarity which is so marked a feature becomes established. Of the two nuclei resulting from the division of the primary nucleus, one moves to the apical (micropylar) end of the sac, the other to the basal (chalazal) end. Two nuclear divisions follow, resulting in four micropylar and four chalazal nuclei. From each of these groups one nucleus, the polar nucleus, moves toward the center of the sac, where it unites with the corresponding nucleus from the opposite end. The three remaining apical nuclei, with their accompanying cytoplasm, constitute the egg apparatus; the three basal ones,

which usually become surrounded by definite cell membranes, form the three antipodal cells. The polar nuclei, either before or after fertilization, fuse to form the primary endosperm nucleus.

The most marked deviations from the typical development observed by the earlier investigators were an increase in the number of archesporial cells (Rosa *sp.*, Helleborus, etc.) and an increase in the number of antipodal cells. Of the latter variations the most marked examples were various species of grasses, first noted by Hofmeister. Further examples of both of these

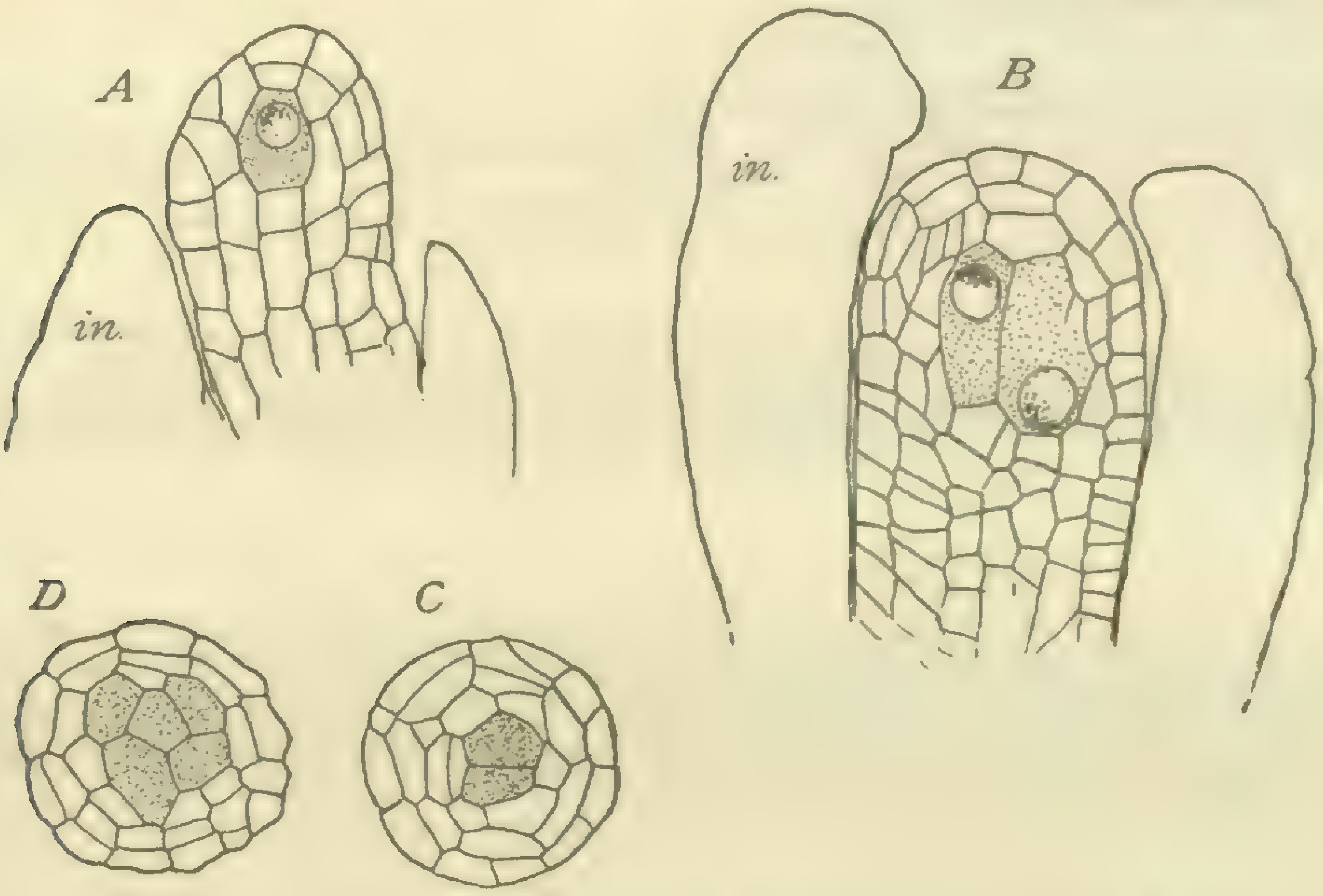

Fig. 2.—Ovules of *Arisæma triphyllum*: *A*, *B*, in longitudinal section; *C*, *D*, transverse sections of the nucellus; the archesporial cells are shaded.

deviations from the type have been recorded by later investigators, and other modifications, not hitherto observed, have been discovered.

The departures from what may be termed the typical development may be referred to several categories. Besides those already referred to, these are three in number: (1) an increase in the number of nuclei before fertilization has taken place; (2) peculiarities in the formation of the endosperm; (3) the so-called double fertilization.

The increased number of archesporial cells observed by Strasburger in *Rosa livida*, *Helleborus cupreus*, and other forms,[1] has been found to occur in a considerable number of forms.

[1] Goebel. *Outlines of Morphology*, etc.

Treub describes a large number of sporogenous cells in Casuarina, several developing into complete embryo sacs. The multicellular archesporium in this case is comparable to that of the pteridophytes and gymnosperms. This increase in the number of sporogenous cells is seen in a lesser degree in *Arisæma triphyllum* (Fig. 2). In the latter the original hypodermal archesporial cell divides longitudinally into 2–4 (occasionally more). One of these, as a rule, becomes at once the embryo sac, but sometimes there are first transverse divisions. It is possible that there may sometimes be more than one primary archesporial cell in Arisæma, *i.e.*, the whole sporogenous tissue may not certainly be referable to the division of a single hypodermal cell. This point, however, needs further investigation.

CASUARINA.

The very peculiar genus Casuarina, according to Treub's investigations,[1] differs decidedly from the other angiosperms, not only in the large development of the sporogenous tissue of the ovule, but also in the structure of the developed embryo sac. This has no antipodal cells, and all the cells of the egg apparatus, which are variable in number, are formed from the division of a primary cell. The egg, moreover, is surrounded by a cellulose membrane before fertilization takes place, a condition unknown among other angiosperms. Before the egg cell divides (and Treub believes before it is fertilized) there is a rapid increase in the number of endosperm nuclei. A demonstration of the actual fertilization was not made, and this point must remain for the present in doubt. Should it be verified, it might well be compared with the condition existing in Peperomia.

PEPEROMIA.

In the genus Peperomia the writer[2] found that there is normally a doubling of the nuclei of the embryo sac before fertilization; *i.e.*, instead of the eight nuclei usually found in the mature embryo sac, there are sixteen (Fig. 3). This fact

[1] *Loc. cit.*

[2] Campbell. The Embryo Sac of Peperomia, *Annals of Botany*, vol. xv (March, 1901), pp. 103–118.

was confirmed by Johnson,[1] who also discovered that the endosperm nucleus was the product of the fusion of several nuclei, instead of two, as in the typical angiosperms. In Peperomia there is no clearly defined egg apparatus, nor are there any proper antipodal cells, although a varying number of nuclei become enclosed in cell membranes and form small flattened cells applied to the wall of the embryo sac. It is to be hoped that a further study of the embryo sac of Casuarina may be made, employing carefully stained microtome sections. A comparison with the embryo sac of Peperomia would be of great interest.

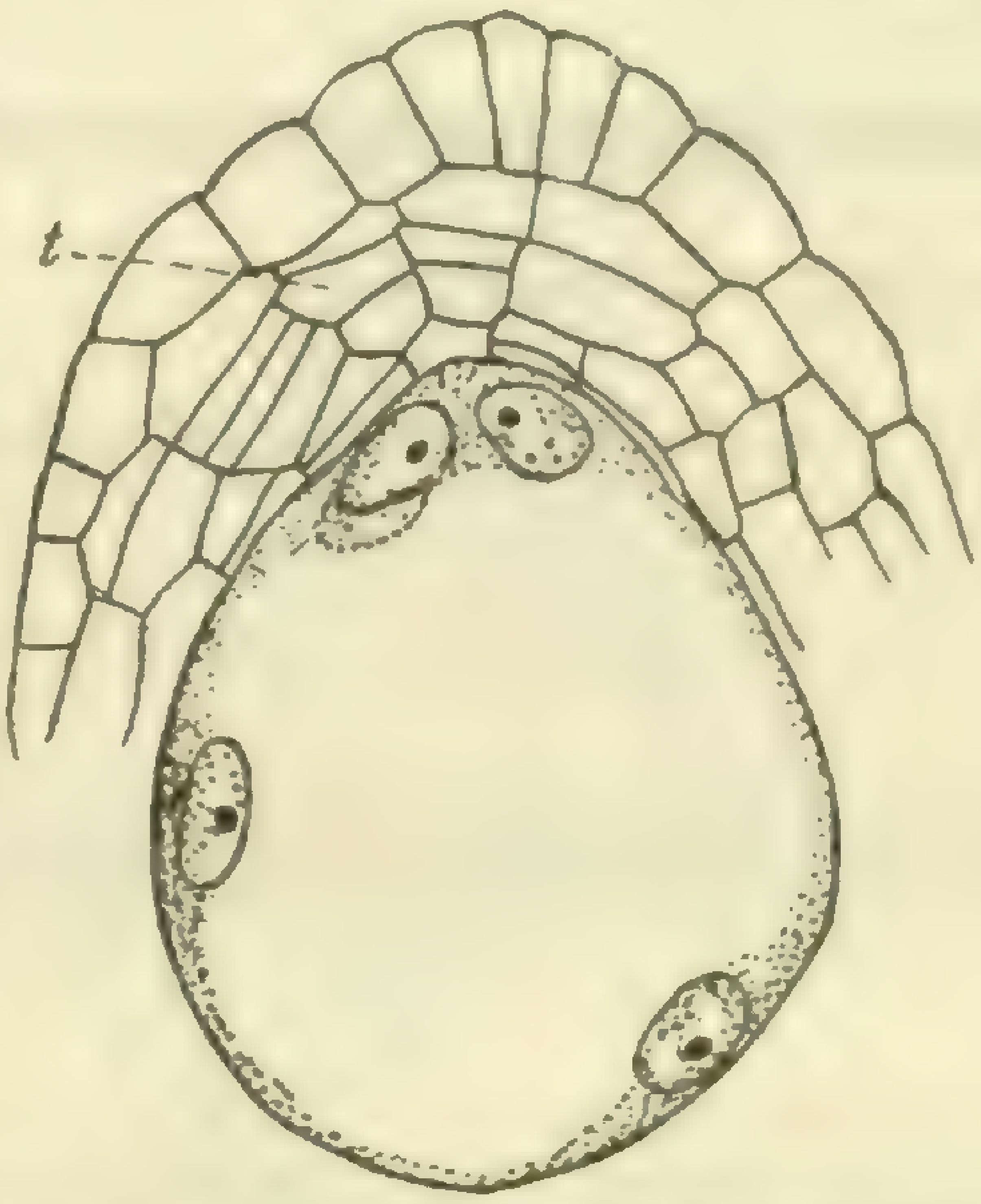

FIG. 3. — A nearly medium longitudinal section of the embryo sac of *Peperomia pellucida*: there were present sixteen free nuclei, of which six are visible in this section.

The increased number of nuclei in the embryo sac of Peperomia, while intermediate in character between that of the typical angiosperms and the lower vascular plants, might equally well be compared with that of the gymnosperms or the heterosporous pteridophytes. The nearest approach to it is found in Gnetum,[2] where the structure is not dissimilar, no true archegonium being present, but the egg cell being developed from one of the free nuclei. However, as the affinities of Gnetum are very obscure, this resemblance does not necessarily imply any connection between Peperomia and the typical gymnosperms.

An increased number of nuclei in the unfertilized embryo sac has been recorded as an occasional variant in several low monocotyledons, — *e.g.*, Naias, Zannichellia, Sparganium, — but in all these forms the normal embryo sac is of the ordinary angiospermous type.

[1] Johnson. On the Endosperm and Embryo of Peperomia pellucida, *Botanical Gazette*, vol. xxx, July, 1900.

[2] Lotsy. Contributions to the Life-History of the Genus Gnetum, *Annales du Jardin Botanique de Buitenzorg*, tome xvi (1899), pp. 46–114.

Karsten. Beiträge zur Entwickelungsgeschichte der Gattung Gnetum, *Botanische Zeitschrift*, Bd. l, 1892.

VARIATION IN THE ANTIPODAL CELLS.

The three antipodal cells commonly found at the chalazal end of the embryo sac are frequently looked upon as merely vestigial structures, as in many cases they doubtless are. That they may be of importance physiologically has been

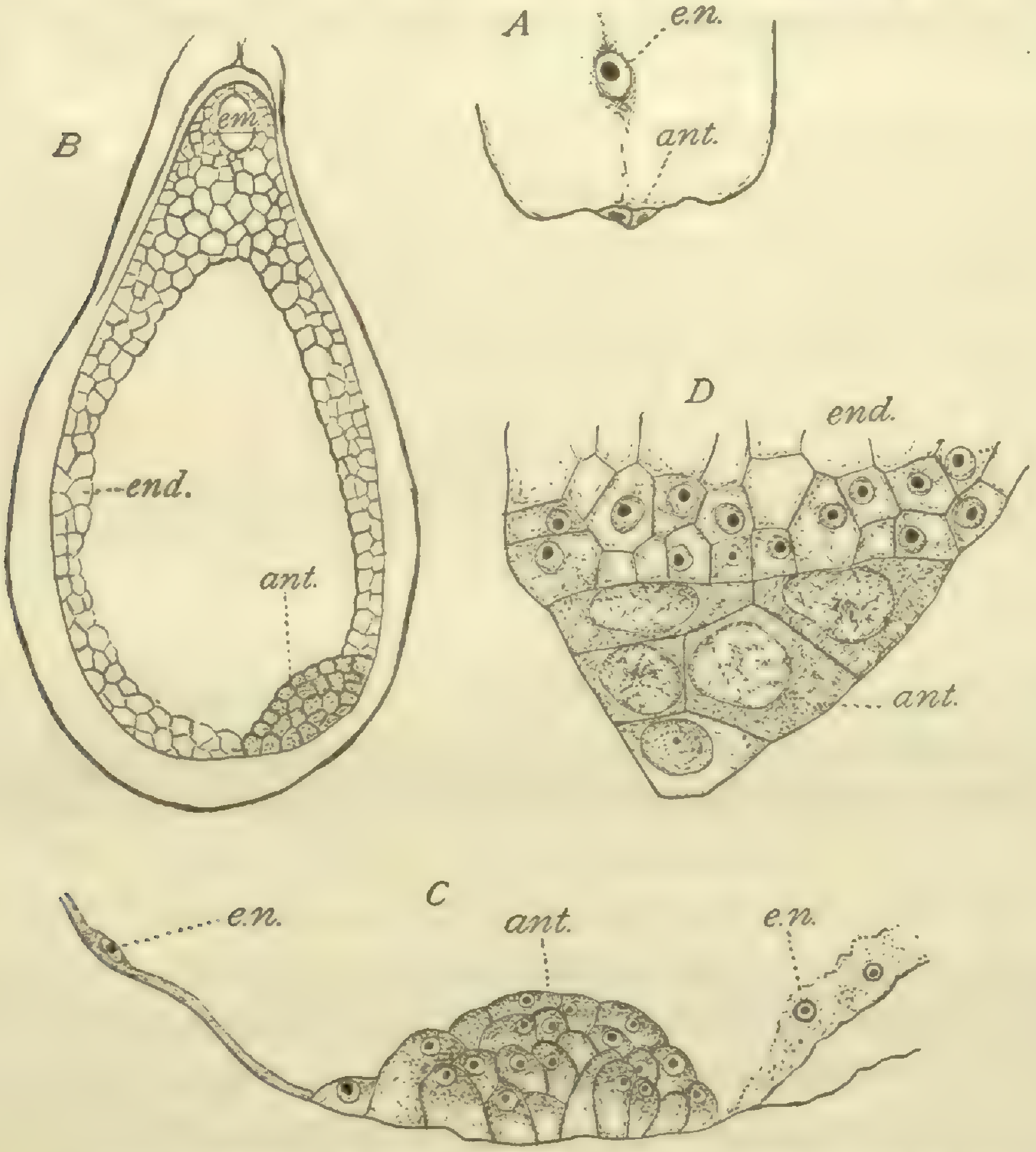

FIG. 4.—*A*, the chalazal end of the embryo sac of *Sparganium simplex*, about the time of fertilization: *e.n.*, endosperm nucleus; *ant.*, two of the three antipodal cells. *B*, section of a young seed of the same species: *em.*, embryo; *end.*, endosperm; *ant.*, the large mass of antipodal cells. *C*, antipodal cells and young endosperm from a somewhat earlier stage, more highly magnified. *D*, chalazal end of the embryo sac from a young seed of *Lysichiton kamtchatcense*, showing endosperm, *end.*, and the enlarged antipodal cells, *ant.*

repeatedly shown, and there is no question that this is oftener the case than was formerly supposed. In many forms — *e.g.*, Naias, Lilæa — the antipodal cells are large, with abundant cytoplasm, and every indication of being active cells. In other cases, such as some Ranunculaceæ,[1] they become very large,

[1] Mottier. Contributions to the Embryology of the Ranunculaceæ, *Botanical Gazette*, vol. xx, 1895.

and become multinucleate. An increase in the number of antipodal cells was observed as a regular phenomenon in various grasses, by Hofmeister, and has been noted also by later observers, — Cannon[1] found in *Avena fatua* as many as thirty-six. There are in these cases the original three antipodals which subsequently increase by division, this occurring before the egg is fecundated.

The greatest number of antipodal cells yet recorded occurs in *Sparganium simplex* (Fig. 4), where there may ultimately

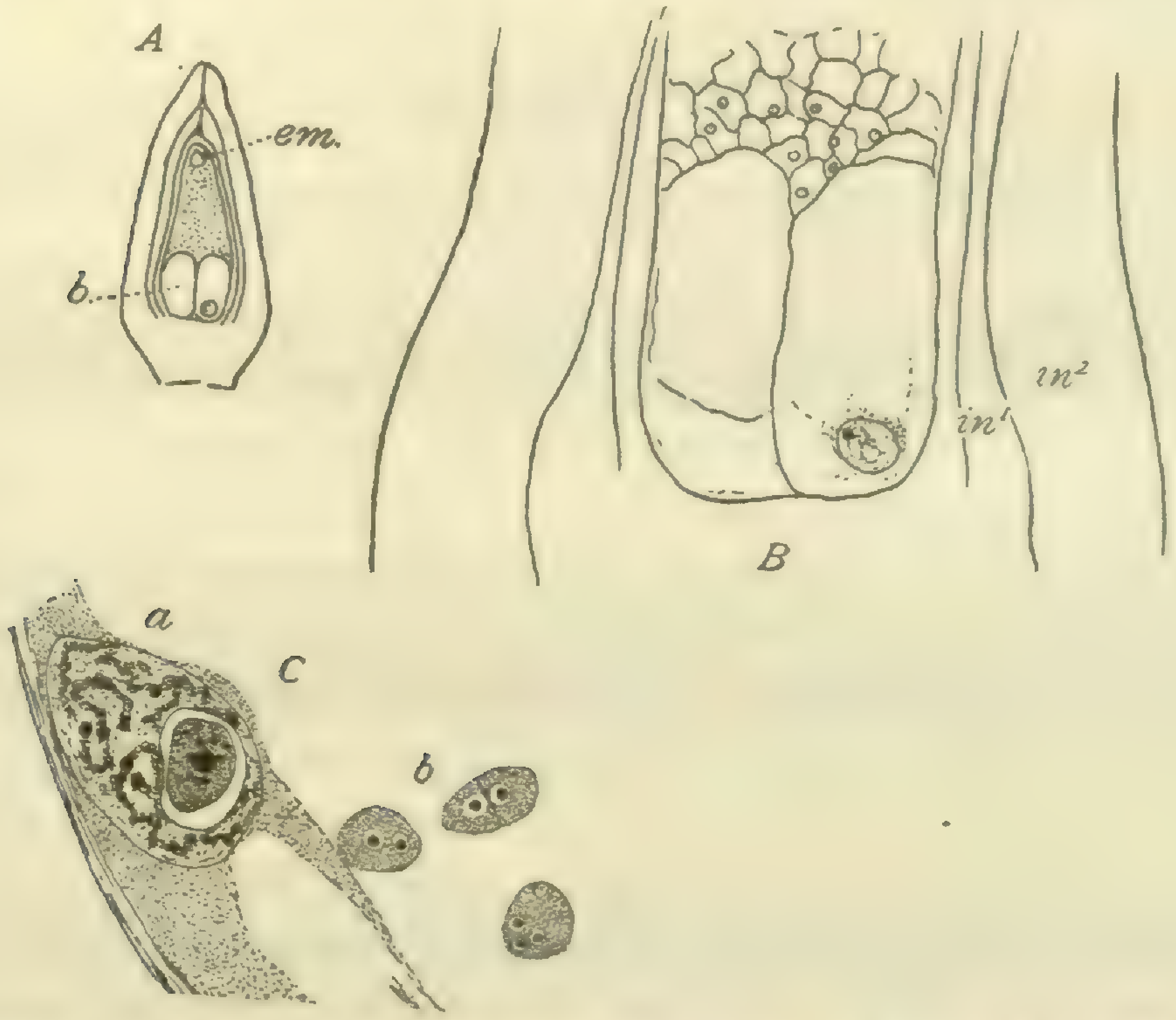

FIG. 5. — *A*, section of young seed of *Spathicarpa sagittæfolia*: *em.*, embryo; *b.*, enlarged basal endosperm cells, × 6. *B*, basal portion of the embryo sac of the same, more enlarged. *C*, the large basal endosperm nucleus, *a*, and the ordinary ones, *b*, from the embryo sac of *Naias flexilis*.

be 150 or more. At the time of fertilization there are but three, small and inconspicuous antipodal cells; but after fertilization these increase rapidly in size and begin to divide actively, forming a very conspicuous hemispherical mass of cells at the base of the embryo sac. This large group of antipodal cells develops while the endosperm is still rudimentary and is doubtless of great physiological importance.

[1] Cannon. A Morphological Study of the Flower and Embryo of the Wild Oat, *Proc. California Acad. of Sciences*, third series, vol. i, No. 10, 1900.

Among other similar cases may be mentioned that of the peculiar aroid, Lysichiton, which occurs upon the northern shores of the Pacific. The original antipodal cells divide in this case also, and their nuclei become enormously enlarged (Fig. 4 *D*).

From a study of the numerous instances which have been studied, it is clear that the antipodal cells are by no means merely vestigial structures, but are often of great physiological importance, replacing the endosperm to some extent, or acting as a medium for the transport of nutriment to the developing embryo.

The Endosperm.

In the typical angiosperms the primary endosperm nucleus resulting from the fusion of the polar nuclei divides to form many free nuclei lying in the peripheral layer of cytoplasm. Walls form between these nuclei, and a layer of tissue is thus developed, lining the embryo sac. By subsequent centripetal divisions the embryo sac becomes finally completely filled with endosperm. When the embryo ultimately fills the whole embryo sac the cell divisions in the endosperm may be entirely suppressed (*e.g.*, Naias). In other cases the first division of the primary endosperm nucleus is followed by a cell wall extending across the cavity of the embryo sac, which is thus filled from the first with tissue.

A modification of the type has been noted in a number of low monocotyledons. Of the two nuclei resulting from the division of the primary endosperm nucleus, only the upper one divides further. The lower one, which may be separated by a wall from the upper part of the embryo sac,[1] sometimes becomes enormously enlarged (Fig. 5 *C*) but does not divide further. It is possible, although this has not been demonstrated, that in some cases there is no fusion of the polar nuclei.

A condition somewhat intermediate between the ordinary form and that just described was recently observed by the writer in *Spathicarpa sagittæfolia*, a South American aroid. In this case (Fig. 5) a group of a few very large cells, with

[1] Schaffner. The Life History of Sagittaria variabilis, *Botanical Gazette*, vol. xxiii, 1897.

enormous nuclei, lies at the base of the endosperm and is sharply separated from the small-celled endosperm in the upper part of the embryo sac. It is probable that the basal group of large cells is the product of the lower of the two nuclei derived from the first division of the endosperm nucleus.

In the genus Peperomia the very large endosperm nucleus is the result of the fusion of several (usually eight) nuclei. It then divides to form the rudimentary endosperm found in the ripe seed.

Double Fertilization.

Much interest has been aroused by the discovery of the so-called double fertilization which has been demonstrated for a large number of angiosperms. This double fertilization consists in the fusion of the second generative nucleus of the pollen spore with the endosperm nucleus, which thus becomes the product of three nuclei. This has led to a theory that the endosperm nucleus is sexual in its nature, and the endosperm arising from it is an embryo. That this view can hardly be maintained is evident from the condition found in Peperomia, which presumably represents a more primitive condition than that of the typical angiosperms. In Peperomia, as already stated, the endosperm nucleus is the product of several similar nuclei, and as such a multiple fusion of sexual cells is quite unknown elsewhere, it is safe to assume that this fusion is not of the nature of a true fertilization.

That the second generative nucleus discharged into the cavity of the embryo sac should fuse with the only available nucleus, the endosperm nucleus, is not surprising. That its character is impressed upon the resulting nuclei is also to be expected. This is shown most clearly in the case of hybrid maize. It has been clearly demonstrated that one type of maize pollinated with another will produce ears in which the endosperm of the grains shows a hybrid character, due presumably to the fusion of one of the pollen nuclei with the endosperm nucleus.[1]

[1] Webber. Xenia, or the Immediate Effect of Pollen in Maize. U. S. Department of Agriculture, Division of Vegetable Physiology and Pathology, *Bulletin No. 22*, 1900.

Summary.

Peperomia, in regard to the embryo sac, probably represents the most primitive form yet described among the angiosperms. The absence of a definite egg apparatus and antipodals, and especially the increased number of nuclei, point to this. The single-celled archesporium of Peperomia is, however, probably less primitive than the multicellular sporogenous complex found in Casuarina and some other forms.

The similarity between the structure of the embryo sac in Peperomia (and perhaps Casuarina) and Gnetum is striking; but as the affinities of the latter are very doubtful, this does not throw much light upon the relationships existing between gymnosperms and angiosperms.

The typical embryo sac may very well have been derived from one like that of Peperomia, by the suppression of one nuclear division. The marked polarity, and the specialization of the egg apparatus and antipodal cells, are probably secondary characters, and the fusion of the polar nuclei has its prototype in the multiple fusion of the nuclei in Peperomia, to form the endosperm nucleus.

Peperomia offers a basis for an explanation of the homologies of the embryo sac. The egg cell probably represents an archegonium reduced to a single cell, and possibly the synergidæ may also represent potential archegonia, although it is quite as likely that they are derived from vegetative prothallial cells.

All of the other structures, the polar nuclei (and their product, the endosperm nucleus) and the antipodal cells, represent vegetative prothallial tissue. The increase in number met with in the antipodal cells of Sparganium, for instance, merely emphasizes their power to assume the rôle of active prothallial tissue.

The fusion of the polar nuclei is in no way to be considered as a true sexual process. The regular occurrence of a multiple fusion in Peperomia is a strong argument against such an assumption. It is much more probable that it is to be interpreted as a stimulus to further growth. The fusion of the second pollen nucleus with the endosperm nucleus must be considered as more or less accidental.[1]

[1] Strasburger. Einige Bemerkungen zur Frage nach der "doppelten Befruchtung" bei den Angiospermen, *Botanische Zeitschrift*, 1899.

THE VASCULAR SYSTEM OF THE COMMON SQUID, LOLIGO PEALII.

LEONARD W. WILLIAMS.

THE knowledge of the histology of the vascular system of the decapod mollusks is very incomplete. The nature and extent of the capillary system especially have been so little understood that two contrary opinions find expression in the text-books of zoölogy. It has been maintained by Lang that the arterial and venous systems are connected partly by capillaries and partly by lacunæ, which are portions of the primary body cavity, while Parker and Haswell affirm that the blood flows through a complete system of capillaries. I have been unable to find any published work which decides between these views. All agree that the vascular system is highly developed and that the capillary system is extensive, but no one seems to have investigated the structure of the vessels or to have determined the exact nature of the so-called lacunæ or sinuses. Prof. Ulric Dahlgren called my attention to this subject, and under his direction I worked upon the vascular system of the squid at Woods Hole during the summers of 1899 and 1900, and at Princeton University during the intervening time. The material, *Loligo pealii*, was furnished me by the Marine Biological Laboratory through the kindness of Professor Dahlgren, and by the United States Fish Commission through the kindness of Dr. H. C. Bumpus, and further material was obtained from the traps at Elberon, N. J.

The extent of the capillary system was determined by injecting the vessels with a saturated aqueous solution of Berlin blue. The injected tissues were studied while fresh and transparent or were fixed in acetic corrosive sublimate or 95 per cent alcohol and mounted in serial sections. The structure of the walls of the vessels was studied after impregnating them with silver in order to show the outlines of the endothelial or other

lining cells. Before injecting the solution of silver nitrate it was necessary to remove the chlorides from the vessels by irrigating them with a 5 per cent solution of potassium nitrate. This solution was followed by a ¼ per cent solution of silver nitrate, and after a few moments this was removed and the tissues fixed by the injection of 95 per cent alcohol. Small pieces of the several organs were dehydrated, cleared in creosote, and mounted. The contraction of the intrinsic muscles of the vessels renders complete injection very difficult, and to obviate this difficulty by dilating the vessels the injection fluids and the water in which the squid were kept were saturated with amyl nitrite. This method was not uniformly successful.

The general arrangement of the vascular system of the squid will be recalled by a glance at the diagram (Fig. 1) of

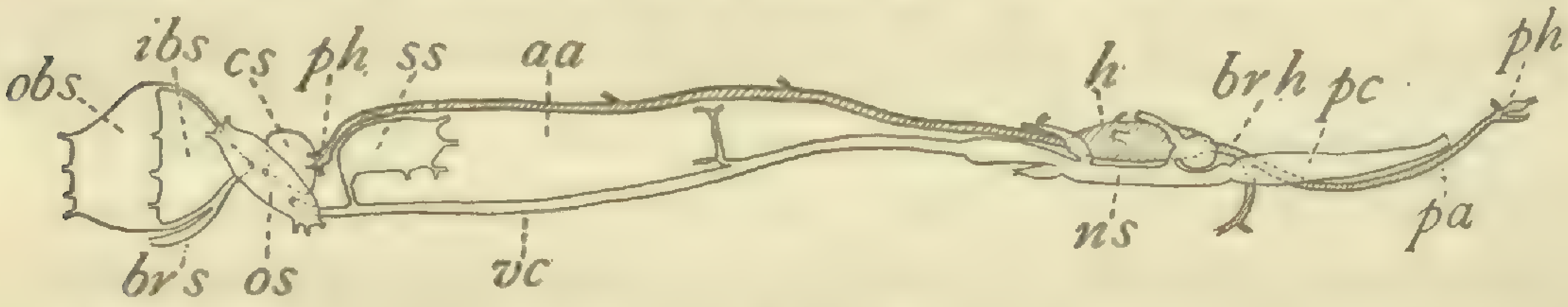

FIG. 1.—Diagram of the vascular system of the squid as seen from the left. *aa*, anterior aorta; *brh*, branchial heart; *brs*, brachial sinus; *cs*, cerebral sinus; *h*, heart; *ibs*, inner buccal sinus; *ns*, nephridial sinus; *obs*, outer buccal sinus; *os*, optic sinus; *pa*, posterior aorta; *pc*, postcava; *ph*, peripheral heart; *ss*, salivary sinus; *vc*, vena cava.

the system seen from the left. Arterial blood enters the one-chambered heart from the gills through the two branchial veins and is forced out through the anterior, posterior, and genital aortæ. The anterior aorta forks near the head, and each branch bears a muscular enlargement, called a peripheral heart, at the point where it breaks up into the branches which supply the head. The two branches of the posterior aorta which pass out of the mantle to the fins also have peripheral hearts. The latter are vascular sphincters, which probably contract synchronously with the mantle, and so prevent the transmission of an excessive blood pressure to the extra-pallial vessels. The blood returning from the arms through the brachial veins reaches the brachial sinus, which is connected with five sinuses, that partially enclose the pharynx, the eyes, and the brain. These sinuses open into the anterior vena cava, which also receives a vein from the sinus that encloses the salivary gland. The anterior

vena cava opens into the apex of the V-shaped nephridial sinus which is surrounded by the nephridial chamber. The venous blood from the dorsal end of the mantle returns through the two postcavæ which open into the ends of the arms of the nephridial sinus. This sinus opens at each side into a branchial heart which forces the blood through the gill to the systemic heart. The sinuses are not interposed between the veins and arteries but receive blood from the veins and return it to the veins. The aortæ, the larger arteries, the branchial arteries and veins, the anterior vena cava, and the postcavæ are all peristaltically contractile. The wave of contraction passes slowly away from the heart along the arteries, and toward the heart along the veins. The peristalsis of the vessels continues long after the stoppage of the hearts and the apparent death of the animal.

The Structure of the Arteries and Veins. — The systemic or arterial heart is composed of smooth muscle fibers. The external surface is firm, but the inner surface is formed by a latticework of interlaced fibers. The great irregularity of this surface interferes with the success of silver impregnations, and although some impregnations and microtome sections indicate that there is an endothelium, such a large number have yielded only negative results that it is probable that an endothelium is not present in the heart. The arterial blood which passes to the tissues of the heart from its lumen becomes venous and is carried to the nephridial sinus by two or three small veins. It is probable that these veins are separated from the lumen of the heart by capillaries. The vessels through which the blood passes are certainly as small as capillaries, but it was impossible to demonstrate an endothelium.

The branchial hearts are quite different from the systemic heart in that the muscle fibers are cross striated and are separated by numerous clusters of apparently glandular polygonal cells, which possibly have a function in connection with the pericardial gland that is attached to the inner edge of the heart and receives a large blood supply from it. Silver impregnation shows that an endothelium is not present and that the muscular and glandular cells are in contact with the blood.

A branch of the posterior aorta brings arterial blood to the tissues of the branchial heart.

The aortæ and the larger arteries are peristaltically contractile and thick walled. Their walls are formed by a thick sheet of peculiar muscular tissue, which is enclosed by two thin coats of connective tissue. The muscular tissue is formed of fusiform cells whose large oval nuclei have a small quantity of protoplasm at each end, but the greater portion of each cell consists of radiating fibers which interlace with those of neighboring cells. The muscle resembles connective tissue more than muscle, but it is actively contractile, for stimuli can be so applied that the peristaltic wave will move in the opposite direction to the blood current, and the peristalsis continues long after the final stoppage of the hearts.

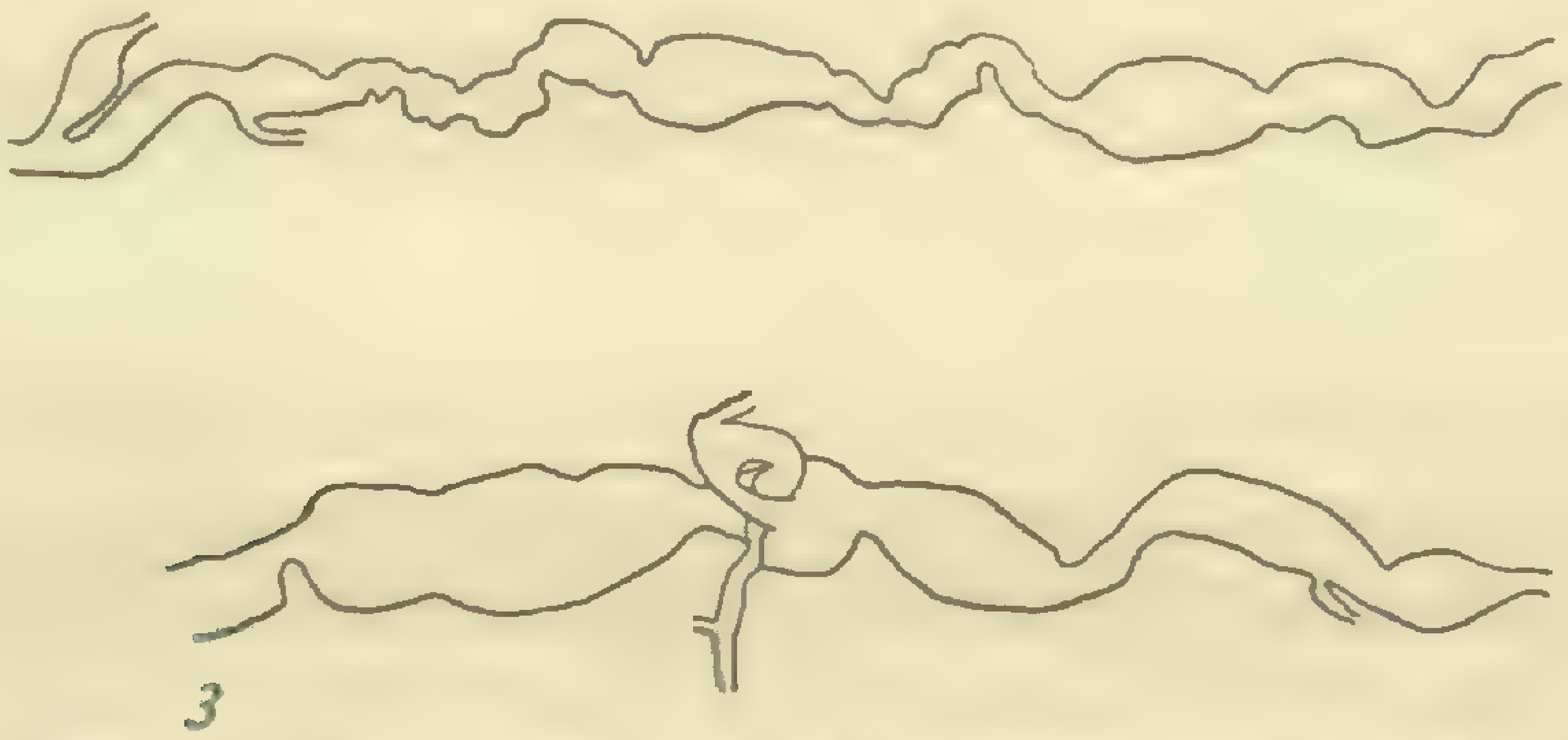

FIG. 2. — Arterioles which show the effect of the contraction of the scattered intrinsic muscle fibers of the vessels.

The muscular coat of the smaller arteries is much thinner, and the peculiar muscle cells are replaced by simple fibers, which are so irregularly distributed upon the smallest arteries that their contraction makes the vessels moniliform, as is shown in Fig. 2. Arterioles arising as lateral branches of an artery commonly have a strong band of muscle fibers at their origin.

The aortæ and their largest branches may have an endothelium, but the unavoidable contraction of their muscular walls throws the inner surface into longitudinal wrinkles, between which the silver is deposited in streaks that obscure the cell outlines. It is probable that an endothelium is present in these vessels; for, although almost all the evidence is negative, a few preparations seem to show the endothelium. The intermediate arteries are lined by an endothelium composed of

flat elongate cells that encircle the vessel. This endothelium gradually merges into the typical endothelium lining the smaller arteries. Bergh[1] found a similar arrangement in the arteries of the pulmonate gasteropods, except that he ascertained definitely that the larger arteries and the heart do not possess an endothelium but are lined by muscle fibers. He concludes that the endothelial cells are undifferentiated (*ungeformte*) muscle cells. There is nothing in the squid which tends to support such an explanation, for the larger vessels are almost certainly lined either by connective tissue or endothelium.

The veins have the same structure as the arteries except that their muscular coat is thinner or wanting and that all have a typical endothelium (Fig. 3). They may readily be distinguished from the arteries by their thinner walls. In many places an artery is accompanied by a pair of veins which anastomose frequently. Fig. 4 represents a portion of such an artery with its companion veins; the narrow initial caliber of the branches of the artery, due to the contraction of the intrinsic muscles of the vessels, should be noted.

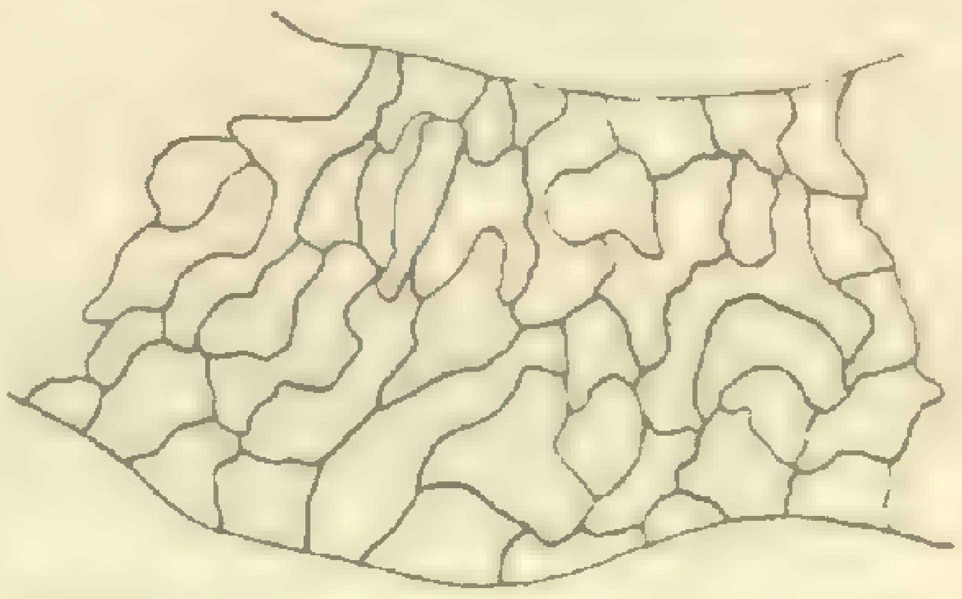
Fig. 3. — Endothelium of a vein. × 260.

The nephridial sinus passes through the nephridial cavity and is invested by the secretory nephridial epithelium. Both surfaces of the sinus wall are increased by interdigitating evaginations from the lumen of the vessel and from the nephridial cavity. The consequent irregularity of the surface of the walls causes many artifacts in silver preparations, so that the cell outlines cannot be followed certainly; nevertheless, sections indicate that an endothelium is present. The nephridial epithelium of the sinus is columnar and is supported by a membrane, the proper wall of the sinus, which carries the nutrient arteries of the wall.

The Capillaries. — The Berlin-blue injections which were intended to demonstrate the extent of the capillary system were perfectly successful. The injection fluid passed from the arteries through the tissues until it filled and flowed from

[1] Bergh, R. S. *Anat. Hefte*, I. Abth., Bd. x.

the veins, so that it is certain that the vascular system was fully injected. Serial sections of many portions of the squid, and gross mounts of portions of the skin, mesentery, and intestinal wall show conclusively that there is a perfect capillary network which connects the arteries and veins in all parts of the body. Like other capillaries, these (Fig. 4) branch and anastomose frequently without altering their diameter, and their walls are formed by an endothelium composed of flat oval cells with sinuous margins. The silver impregnations of the capillaries, though rarely successful, leave no doubt as to the nature of the wall.

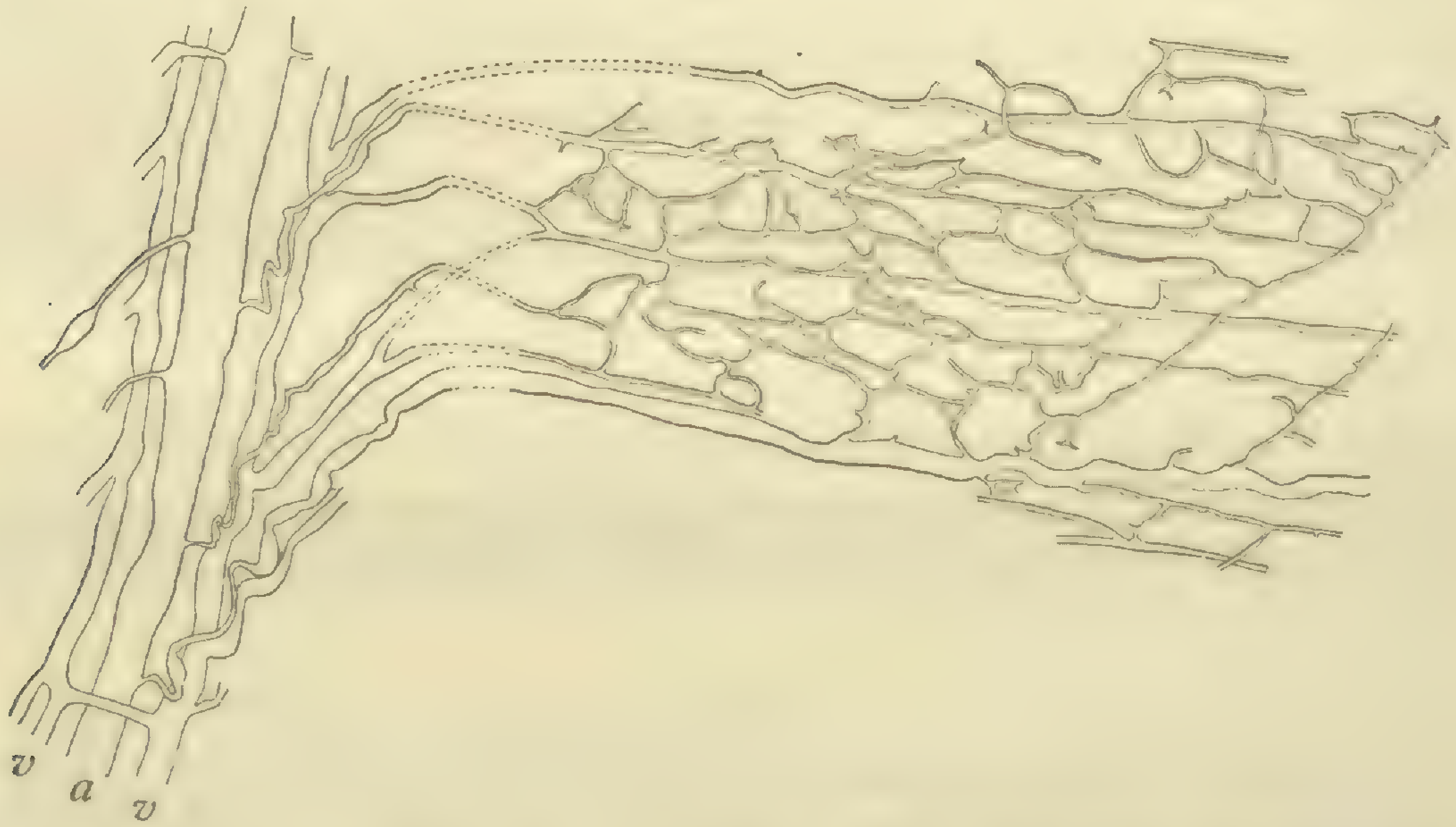

FIG. 4. — Artery, companion veins, and connecting capillaries sketched from the supporting membrane of the gill. *a*, artery; *v*, veins.

Some arterioles and capillaries are connected with lacuna-like cavities which may be called the end sinuses of the veins. Fig. 5 is a camera sketch of such a sinus situated in the visceral body wall. Similar sinuses have been found in the testis, glands, and muscles, and it is very probable that they are more widely distributed. Each sinus is a small irregular cavity, into which an arteriole passes and then breaks up into branches; the latter pass out of the sinus and communicate with the surrounding capillary plexus, some of whose branches open into the sinus, so that the blood must pass through the perforating arteriole and then through the capillaries into the

sinus.[1] The sinuses are connected with the veins by very small vessels. In partially successful injections the colored arteriole can be seen surrounded by a space filled with blood corpuscles, but in perfect injections both the arteriole and the sinus are filled with the injection mass. The arteriole, capillaries, and the sinus are all lined by endothelium. It was impossible to determine whether the endothelium of the sinus was reflected over the surface of the perforating arteriole. It is worthy of note that when the blood had not been driven out of the sinus the proportion of corpuscles in the blood of the sinus was six or eight times as great as in the other vessels, — a fact which

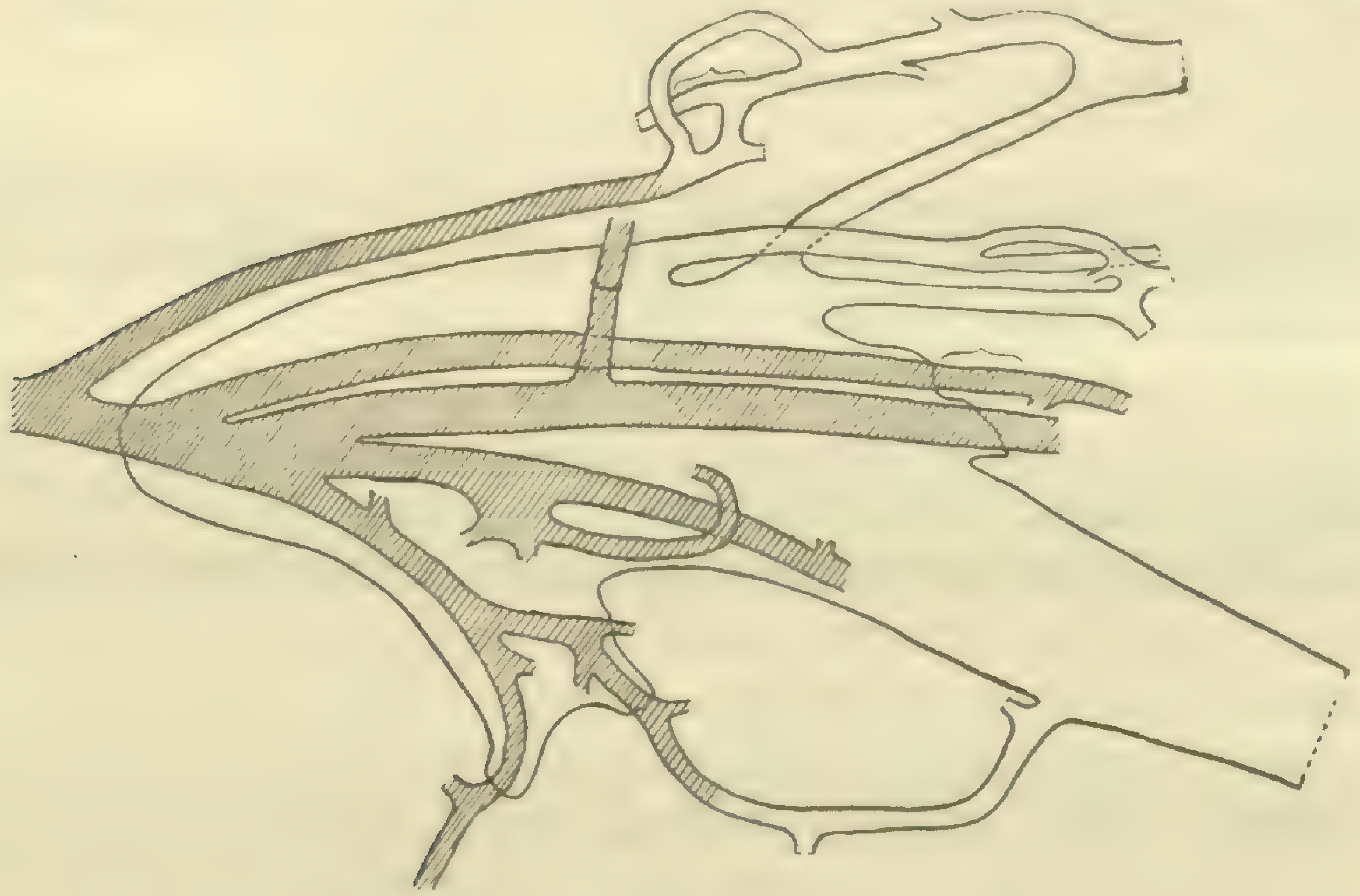

FIG. 5. — End sinus of vein, from visceral body wall.

may be due to the filtering out of the corpuscles as the blood was driven through the vessels by the injection fluids.

The Capillaries of the Gills. —The gills are not easily injected because a valve at the origin of the branchial artery prevents the free flow of injection fluids in either direction. The valve is formed by four tubercles which project in the direction of the blood current into the lumen of the artery. A band of muscle fibers forms a sphincter whose contraction forces the tubercles together so that the lumen of the vessel may be closed.

[1] The connection between these vessels and the veins has been inferred from the course of the injection fluids through the sinus.

Notwithstanding the resistance of this valve, successful capillary injections of Berlin blue were obtained as well as good silver impregnations of the veins and arteries. The capillaries are enclosed between epithelial plates which form the upper and lower surfaces of the gill and are separated from one another by small columns of cells which bind together the gill surfaces. The vascular endothelium could be traced only to the beginning of the capillaries, but microtome sections leave little doubt that the endothelium also extends into the capillaries.

The salivary sinus and the sinuses of the head (brachial, inner and outer buccal, optic, and cephalic), which are usually cited as examples of lacunæ, must be considered to be enormous dilations of the veins. They are so large that it is impracticable to examine every portion of their walls, but silver impregnations of portions of several sinuses show that they are lined by an endothelium. All the sinuses have essentially the same structure, so that the description of one sinus will convey a true conception of all. The outer buccal sinus surrounds the sides and dorsal surface of the oval pharynx as the pericardium invests the heart. The outer wall of the sinus is supported by the muscular ring at the base of the arms, and the inner wall is supported by the pharynx and by the muscular septum which separates the inner buccal sinus from the outer. The walls are formed by connective tissue and by the endothelium which it supports. Ten or fifteen small veins which arise in the peristomial membrane open into the ventral end of the sinus, and the brachial sinus opens into the dorsal end. The blood passes from the buccal sinus through the optic sinuses to the vena cava. Beside having definite walls, these sinuses, unlike lacunæ, do not connect arteries and veins, but receive blood from the veins and return it to the veins. The wide distribution of the capillary vessels, the presence of an endothelium around every blood-containing cavity, except possibly the hearts, and the absence of demonstrable lacunæ, all lead to the conclusion that the arterial and venous vessels of the squid are connected by capillaries so that the vascular system is closed.

BROWN UNIVERSITY.

WINDS AND STORMS AS AGENTS IN THE DIFFUSION OF INSECTS.[1]

F. M. WEBSTER.

By the term "winds" I wish to include even the mildest breezes as well as the strongest gales, the latter, either alone or in connection with thunderstorms, such as may and ordinarily do occur in our latitude during the warm months of the year. Throughout the northern states the keen, biting March winds find comparatively few insects abroad to be caught up, or who willingly surrender themselves to its power; and in late autumn, when the breeding season is nearly or quite over with the majority of species, they seem to prefer the quiet of the Indian summer to move about. In the one case, diffusion appears to be the one overwhelming object; while in the other, the object seems to be to reach particular locations or conditions that will best protect from the winter blasts which are to come later on in the year.

Whatever conduces to diffusion, must, as a rule, tend to increase fecundity — first by bringing the sexes together during the mating seasons, and second by enabling them to secure a greater food supply.

The effect of even very light breezes in enabling the sexes to meet at the proper time may be well illustrated by placing a female of some of our larger moths in a wire cage, and, hanging this in the open, noting the number of males that will soon be attracted and remain hovering about the cage, making every effort to reach the female within. The same may be observed in many Hymenoptera. It will be noted further that these males come to the cage against and not with the wind. With a continual absolute quiet, how much less liable would the sexes be to reach each other at the proper time for mating,

[1] Read before Section F, Zoölogy, American Association for the Advancement of Science, July 1, 1902.

especially such as are wingless among the females, or which, having wings, do not readily use them? If we trap insects by baits or by lights, we find that our catches will be largely of males or spent females, thus showing that, generally speaking, the male seeks the female. In the cases of some of our hymenopters and especially where males do not, or rarely, occur, and with others, like the Aphides, where the males only occur at a single definite time, this rule will not hold good, and our captures will be all of them females; and I think it is among such that will be found those that give themselves most freely to the embraces of the winds during the breeding seasons.

The influence of the winds in enabling insects to detect the location of their food is apparent in many ways. If we place the dead body of a bird, snake, or small animal under a bell glass in the fields, no carrion-loving insects will come to it; but if we substitute for the bell glass a wire cage, these will soon find their way to it, coming against and not with the wind. The two species of dung beetles, *Aphodius inquinatus* and *A. serval*, which appear, the one in the fall and the other in the spring, quickly find the fresh droppings of animals by aid of the wind. The plum curculio, *Conotrachelus nenuphar*, is said to approach a plum orchard more readily against the wind than with it, as has been determined by painting individuals and liberating them to the windward and leeward of a plum orchard just at the season for oviposition; and there is little doubt but that many of our wood-boring beetles are enabled to select a weakened tree by their acute sense of smell. Thus do the light winds enable many insects the better to find their food and each other, thereby greatly increasing their numbers in any given place.

The high winds and gales, unaccompanied by rain, thunder, and lightning, also exert a powerful influence in the diffusion of insects. But before taking up the direct subject of influences of high winds exclusively, it may be well to call attention to some of the effects of prevailing winds, that is, winds both light and heavy but which come most continuously from one direction during the period when insect diffusion is most susceptible to their influences. A most convincing illustration in

this direction is offered by the spread of the San José scale in orchards, especially in the Middle West. If infested trees, brought from the nursery and transplanted to the orchard, happen to be set along the north or east margins of an orchard, the spread through that orchard is comparatively slow; but on the other hand, if the infested trees happen to be placed along the west or south margins, the progress is much more rapid. So also, where the introduction is into a section of country largely devoted to tree fruits, the spread over the country is much more rapid towards the northeast than in any other direction. This is for the reason that our prevailing winds, during the period when the young are carried from one place to another by these winds, blow from the southwest or west, more generally the former. In the case of the Hessian fly, *Cecidomyia destructor*, I have noted that, where a field of wheat has been seriously attacked in the fall, and adjoining fields have escaped, some of these last may be seriously attacked the following spring, while others seemingly equally exposed to attack almost entirely escape injury. A careful examination into the facts, however, will show that this is due to the direction of the prevailing winds at the time when the spring brood of flies were abroad, and the wind simply carried them toward those fields that were located in one direction and away from those located in the opposite direction, thereby to a certain extent protecting the one from attack and causing the destruction of the other. In the case of the San José scale, active only in the very young larva, I have noted that, where infested trees happen to be placed in a gully extending up a steep hill, the spread will be much more rapid upward than downward, as the air current is in that direction. So, then, prevailing winds have in some cases much to do with the spread of insects in certain directions. The influence of high winds on insects is illustrated in one way by the great number of butterflies that are sometimes encountered by ships at sea, long distances from land. Indeed, the entomological fauna of very many of the islands of the sea indicates very strongly that insects have become established on such islands by having been blown from the mainland, or from other islands located at considerable

distances away.[1] Dr. Henry C. McCook, in his great work on *American Spiders and their Spinning Work*, has shown how the huntsman spider, *Heteropoda venatorius*, on account of its aeronautic habits, might well have circumnavigated the globe with the aid of the trade winds, basing his calculations on the localities where the spider is known to occur and the direction of these winds. The late Dr. D. S. Kellicott told me of the sudden appearance of considerable numbers of the cotton-worm moth, *Aletia argillacea*, at Columbus, Ohio, immediately following a gale from the southwest; and, besides, we know that this moth has been found as far north as western Ontario, with no evidence of its having developed there in a single instance. Years ago, while studying the habits of the buffalo gnat, in the Southern States, one of the most perplexing questions that confronted the planter, relative to the habits of this bloodthirsty insect, was their sudden appearance in a locality in such immense swarms as to kill thousands of head of cattle, mules, and other domestic animals, before these could be gotten to a place of safety. Early in my investigations, I found that the adult gnats emerged from the waters of the bayous and clustered upon the surrounding vegetation in such numbers as to fairly cover the same, and a sudden high wind would carry these gnats along with it and distribute them for miles over the cotton plantations, there to carry on their bloody work. Thus, these insects might appear suddenly in immense numbers, ten or twelve miles from their place of breeding, in one direction, while in the direction opposite they might not occur

[1] Since the preparation of this paper the following note has come to me:

The 'Blue Page' Moth. — During the gale that reached Barbados and St. Vincent on August 26, 1901, numbers of a large moth were found in Barbados, of a kind not known to breed there. They had evidently been brought by the high southwest wind. Some were caught and identified as *Urania sloanei*, the 'blue page' of Trinidad, and they had apparently come from the mainland or, more probably, from Trinidad itself. They were found as far north as Dominica, and one was caught on the R. M. S. 'Eden' midway between St. Lucia and Barbados. This is an excellent instance of how insects spread from island to island, and had these moths found suitable conditions in Barbados, they might have become established there and formed an addition to the permanent fauna. The direct distance from Trinidad to Barbados is about 160 miles, and to Dominica is some 100 miles more. — *The* (Barbados) *Agricultural News*, June 7, 1902.

at all, — the direction depending on that of the wind; and a wind prevailing from the same direction during the breeding season one year would affect a certain territory, while the following year the prevailing winds might be from another quarter, and so cause these insects to terrorize an entirely different section of country. Formerly, and before the advent of the electric motor as a means of propelling street cars, when these gnats developed, during some seasons, in the St. Francis bottoms, across the Mississippi River west of Memphis, Tenn., these insects might occur in their breeding grounds in immense swarms, but so long as the prevailing winds were from an easterly direction few of them would be observed in Memphis; but let a strong gale set in suddenly from the west and these bloodthirsty insects would suddenly appear in such numbers as to prevent the running of the street cars, which were then drawn by mules; these last would be killed in their harnesses, and the cars were necessarily abandoned until these gnats disappeared. Of course the introduction of electricity, and the disappearance of the mules as a means of motive power has, in this case, overcome the difficulty, but former conditions offered a good illustration of the far-reaching influences of the wind on some insects. It may be mentioned that the gnats that were so driven about by the wind were all sterile females and the species was not, in this particular case, permanently diffused by this means. Somewhat similar effects of winds are to be observed as affecting the various species of migratory locusts, the exact territory devastated by them often being dependent on the direction of the prevailing winds during the migrating season.

Relative to the concluding point in this paper, *viz.*, the influence of wind and thunderstorms combined on insect diffusion, I beg to call attention to a most interesting series of papers contributed to *Prometheus*, a German scientific journal much like our *Scientific American*, by Prof. Karl Sajö, of Budapest, Hungary. Professor Sajö says that it is known that "before thunderstorms the crayfish come out of the water into the grass on the banks of the river or lake; many fishes act as if they were insane, and many birds and mammalia become

irritated and angry. Even the micro-organisms are subject to similar changes; for instance, before thunderstorms in late fall, the wine fermentation can reach so great a violence as to cause the fermenting juice to suddenly run out of the vats. The greater the change in the atmosphere, the greater the unrest of the living being." If one happens to be at a farmhouse in our own country, where ice is not freely used, and a thunderstorm occurs, any farmer's wife will complain that the thunder and lightning have soured the milk. Continuing, Professor Sajö calls particular attention to the "great unrest and activity that takes place in the insect world just in the sultry hours preceding a thunderstorm, and to the fact that insects in the air at the time the storm bursts are driven like chaff to great distances, — perhaps into other countries, across rivers, lakes, and mountains; not only the species that fly but many that do not fly may thus be transported to new homes." And again, "Many Aphides creep to the crowns of the plants, then drop themselves at the proper moment into the violent current of the storm. A number of these insects land in places where there is no food supply for them and they die. A part of them reach places where their species is already established, and fare no better. Part are thrown into the water, sometimes in oceans, and perish. A proportionally small number arrive at such places as may be called really favorable for their diffusion, *viz.*, where the species has never established itself before, or, having done so, died out before the arrival of newcomers, and, therefore, natural enemies had not preceded them. Such individuals as are thus thrown into favorable places have a chance to multiply into large, populous colonies within a short space of time, and continue until their enemies find them out, or they become over-populous and devour all of their food supply, resulting in what to them is famine."

There is probably not an American entomologist who has not encountered illustrations similar to those enumerated by the writer of the above, and, while we may not have wholesale introductions of new things among us, there is no doubt that localities are often first colonized by certain kinds of insects in this manner, whereas the wind or the

thunderstorm acting separately would not bring about such a condition of affairs.

I have stated that, in applying trap lights or lanterns, or edible baits like sweetened sour beer, we, as a rule, secure males and spent females, but the influence of weather conditions that usually precede a thunderstorm (that is, a close, sultry condition) has the effect of bringing out both sexes, — a result due, so far as can now be determined, to some subtile action on their sexual life. As Professor Sajö so aptly illustrates this point, I will quote him again quite fully. "What influence the weather has, especially on the activity of sexual life, must be known to every zoölogist; even man is not an exception from these 'living barometers.' Not only children, not only the female sex, but the sick ones experience the influence of the weather on the functions, especially on the nervous system; and everybody without exception are thus influenced, though not all may be aware of the fact. The same causes that in many produce unrest and irritation render others dizzy, stupid, or sleepy, according to the temperament of the individual." The effect of electricity on the nervous systems of insects, especially as relative to their love affairs, would constitute an interesting study, and one that ought to be carried out; but even as it is, we can see that the thunderstorm, in conjunction with the wind, may accomplish in the diffusion of insects that which neither element alone would bring about.

THE COLORS OF FISHES.

DAVID STARR JORDAN.

Pigmentation.—The colors of fishes are in general produced by oil sacs or pigment cells beneath the epidermis or in some cases beneath the scales. Certain metallic shades, silvery blue or iridescent, are produced, not by actual pigment, but, as among insects, by the deflection of light from the polished skin or the striated surfaces of the scales. Certain fine striations give an iridescent appearance through the interference of light.

The pigmentary colors may be divided into two general classes, ground coloration, and ornamentation or markings. Of these the ground color is most subject to individual or local variation, although usually within narrow limits, while the markings are more subject to change with age or sex. On the other hand, they are more distinctive of the species itself.

Protective Coloration.—The ground coloration most usual among fishes is protective in its nature. In a majority of fishes the back is olivaceous or gray, either plain or mottled, and the belly white. To birds looking down into the water, the back is colored like the water itself or like the bottom below it. To fishes in search of prey from below, the belly is colored like the surface of the water or the atmosphere above it.

In shallow waters or in rivers the bottom is not uniformly colored. The fish, especially if it be one which swims close to the bottom, is better protected if the olivaceous surface is marked by darker cross streaks and blotches. These give the fish a closer resemblance to the weeds about it or to the sand and stones on which it lies. As a rule, no fish which lies on the bottom is ever uniformly colored.

In the open seas, where the water seems very blue, blue colors, and especially metallic shades, take the place of olivaceous gray or green. As we descend into deep water, especially

in the warm seas, red pigment takes the place of olive. At a depth of 50 to 150 fathoms in the tropics a large percentage of the fishes are of various shades of red. Several of the large groupers of the West Indies are represented by two color forms, a shore form in which the prevailing shade is olive green, and a deeper water form which is crimson. In one case an intermediate color form also exists, which is lemon yellow. On the coast of California is a band-shaped blenny which appears in three colors, according to its surroundings, blood red, grass green, and olive yellow. The red coloration is also essentially protective, for the region inhabited by such forms is the zone of the rose-red algæ. In the arctic waters, and in lakes where rose-red algæ are not found, the red ground coloration is almost unknown, although red may appear in markings or in nuptial colors. It is possible that the red, both of fishes and algæ, in deeper water is related to the effect of water on the waves of light, but whether this should make fishes red or violet has never been clearly understood. It is true, also, that where the red in fishes ceases violet black begins.

In the great depths, from 500 to 4000 fathoms, the ground color in all fishes becomes deep black or violet black. This shade is also protective. In these depths the sun's rays scarcely penetrate, and the fish and the water are of the same apparent shade, for black coloration is here the mere absence of light.

In general, the markings of various sorts grow less distinct with the increase of depth. Bright red fishes of the depths are usually uniform red. The violet-black fishes of the oceanic abysses show no markings whatever (luminous gland excepted), and in deep waters there are no nuptial or sexual differences in color.

Ground colors other than olive green, gray, brown, or silvery rarely appear among fresh-water fishes. Marine fishes in the tropics sometimes show as ground color bright blue, grass green, orange yellow, or black; but these showy colors are almost confined to fishes of the coral reefs, where they are often associated with elaborate systems of markings.

Protective Markings. — The markings of fishes are of almost every conceivable character. They may be roughly grouped as protective coloration, sexual coloration, nuptial coloration, recognition colors, and ornamentation, if we may use that term for brilliant hues which serve no obvious purpose to the fish itself.

Examples of protective markings may be seen everywhere. The flounder which lies on the sand has its upper surface covered with sandlike blotches, and these again will vary according to the kind of sand it imitates. It may be true sand or crushed coral or the detritus of lava, in any case perfectly imitated.

Equally closely will the markings on a fish correspond with rock surroundings. With granite rocks we find an elaborate series of granitic markings, with coral rocks another series of shades, and if red corals be present, red shades of like appearance are found on the fish. Still another kind of marks indicates rock pools lined with the red calcareous algæ called Corallina. Black species are found in lava masses, grass-green ones among the fronds of ulva, and olive-green among Sargassum or fucus, the markings and often the form corresponding to the nature of the algæ in which the species makes its home.

Sexual Coloration. — In many groups of fishes the sexes are differently colored. In some cases bright red, blue, or black markings characterize the male, the female having similar marks, but less distinct, and the bright colors replaced by olive, brown, or gray. In a few cases, however, the female has marks of a totally different nature, and scarcely less bright than those of the male.

Nuptial Coloration. — Nuptial colors are those which appear on the male in the breeding season only, the pigment afterwards vanishing, leaving the sexes essentially alike. Such colors are found on most of the minnows and dace (Cyprinidæ) of the rivers and to a less degree in some other fresh-water fishes, as the darters (Etheostominæ) and the trout. In the minnows of many species the male in spring has the skin charged with bright pigment, red, black, or bright silvery, for the most part, the black most often on the head, the red on the head and body, and the silvery on the tips of the fins.

At the same time other markings are intensified, and in many species the head and sometimes the body and fins are covered with warty excrescences. These shades are most distinct on the most vigorous males, and disappear with the warty excrescences after the fertilization of the eggs.

Nuptial colors do not appear among marine fishes, and in but few families are the sexes distinguishable by differences in coloration.

Recognition Marks.—Under the head of "recognition marks" may be grouped a great variety of special markings, which may be conceived to aid the representatives of a given species to recognize each other. That they actually serve this purpose is a matter of theory, but the theory is plausible, and these markings have much in common with the white tail feathers, scarlet crests, colored wing patches, and other markings regarded as recognition marks among birds.

Among these are ocelli, black or blue ringed with white or yellow, on various parts of the body; black spots on the dorsal fin; black spots below or behind the eye; black, red, blue, or yellow spots variously placed; crossbars of red or black or green, with or without pale edges; a blood-red fin among pale ones or a fin of shining blue; a white edge to the tail; a yellow, blue, or red streamer to the dorsal fin, a black tip to the pectoral or ventral; a hidden spot of emerald in the mouth or in the axil; an almost endless variety of sharply defined markings, not directly protective, which serve as recognition marks, if not to the fish itself, certainly to the naturalist who studies it.

These marks shade off into an equally great variety for which we can devise no better name than "ornamentation." Some fishes are simply covered with brilliant spots or bars or reticulations, their nature and variety baffling description, while no useful purpose seems to be served by them, unless we stretch still more widely the convenient theory of recognition marks.

In many cases the markings change with age, certain bands, stripes, or ocelli being characteristic of the young and gradually disappearing. In such cases the same marks will be found permanent in some related species of less differentiated coloration. In such cases it is safe to regard them as ancestral.

In case of markings on the fins and of elaborate ornamentation in general, it is best defined in the oldest and most vigorous individuals, becoming intensified by degrees.

Intensity of Coloration. — In general, coloration is most intense and varied in certain families of the tropical shores, and especially about coral reefs. But in brilliancy of individual markings some fresh-water fishes are scarcely less notable, especially the darters (Etheostominæ) and sunfishes (Centrarchidæ) of the streams of eastern North America. The bright hues of these fresh-water fishes are, however, more or less concealed in the water by the olivaceous markings and dark blotches of the upper parts.

Coral Reef Fishes. — The brilliantly colored fishes of the tropics seem to scorn the need of protective coloration. They save themselves from their enemies in most cases by excessive alertness and activity (Chætodon, Pomacentrus), or else by burying themselves in coral sand (*Jules gaimardi*), a habit more frequent than has been suspected.

Fading of Pigments in Spirits. — In the preservation of specimens most red and blue pigments fade to whitish, and it requires considerable care to interpret the traces which may be left of red bands or blue markings. Yet some blue pigments are absolutely permanent, and occasionally blood-red pigments persist through all conditions. Black pigment seldom changes in spirits, and olivaceous markings simply fade a little without material alteration. It is an important part of the work of the systematic ichthyologist to learn to interpret the traces of the faded pigment left on specimens he may have occasion to examine. In such cases it is more important to trace the markings than to restore the ground color, as the ground color is at once more variable with individuals and more constant in large groups. In other words, it varies a good deal, but in almost constantly narrow limits.

Variation in Pattern. — Occasionally, however, a species is found in which, other characters being constant, both ground color and markings are subject to a remarkable range of variation. In such cases the actual unity of the species is open to serious question. The most remarkable case of such variation

known is found in a West Indian fish, the vaca, which bears the incongruous name of *Hypoplectrus unicolor*. In the typical vaca the body is orange with black marks and blue lines, the fins checkered with orange and blue. In a second form the body is violet, barred with black, the head with blue spots and bands. In another form the blue on the head is wanting. In still another the body is yellow and black, with blue on the head only. In others the fins are plain orange, without checks, and the body yellow, with or without blue stripes and spots, and sometimes with spots of black or violet. In still others the body may be pink or brown, or violet black, the fins all yellow, part black or all black. Finally, there are forms deep indigo blue in color everywhere, with cross bands of indigo black, and these again may have bars of deeper blue on the head or may lack these altogether. I find no difference among these fishes except in color, and no way of accounting for the differences in this regard.

A species of puffer (*Tetradon setosus*) shows similar remarkable variations, being dark gray with white spots, but varying to indigo blue, lemon yellow, or sometimes having coarse blotches of either. Lemon-yellow varieties of several species are known, and these may be due to a failure of pigment, a sort of semi-albinism. True albinos, individuals wholly without pigment, are rare among fishes.

FLOWERS AND INSECTS IN NEW MEXICO.

T. D. A. COCKERELL.

In a certain sense we may say correctly that the flora of our country is fairly well known. New species, and even genera, are frequently described, but most of these are segregates from the more comprehensive groups of earlier authors, and radically new types are not often met with. Nevertheless, there is hardly a plant upon which new observations may not be made with ease. Our whole flora needs redescribing from living plants, every species needs close study to determine the character and range of its variations, and the relations between plants and insects offer a field for research which appears practically inexhaustible. The following notes record the results of some recent researches, and may serve as a contribution to entomophytology. They are classified according to locality.

Rio Ruidoso, White Mountains.

This is an alpine region in southern New Mexico, possessing a remarkably interesting flora, with quite a number of apparently endemic types. Prof. C. H. T. Townsend collected there a large number of bees, together with the flowers on which they were found. Some of these have been recorded, but the following data are new:

(1) *Verbena macdougalii* Heller. A very common species in New Mexico, formerly regarded as *V. stricta*, but separated by Heller on what seem to be perfectly valid grounds. The lilac-purple flowers are arranged in long spikes, so that the plant looks entirely different from the ordinary kinds of Verbena, which are adapted to butterflies. At the foot of Baldy Mountain, near Elizabethtown, Mrs. O. St. John found a variation (mut. nov. *rosella*) with pink flowers. The ordinary form was growing at the same place, which had an altitude of about 9600 feet.

Although our common types of Verbena (*V. macdougalii*, *V. bipinnatifida*, and *V. bracteosa*) look so entirely different, they all have the throat of the corolla covered with the same peculiar moniliform hairs.

V. macdougalii is an excellent bee plant. On the Rio Ruidoso, Townsend collected from the flowers the following bees: *Anthophora cleomis* Ckll. ♀, *A. montana* Cress. ♀, *Clisodon terminalis* Cress., *Anthidium maculosum* Cress., *Anthophora californica* Cress. ♂, *Megachile fortis* Cress., *Melissodes ruidosensis* Ckll., *Synhalonia crenulaticornis* Ckll. ♂, *Calliopsis rhodophilus* Ckll. ♀. It will be noted that these are long-tongued bees.

(2) *Monarda stricta* Wooton. Another very common New Mexico plant, only lately recognized as a distinct species. Its conspicuous heads of pink flowers are attractive to certain long-tongued bees, of which Townsend collected *Anthophora cardui* Ckll. ♂, *A. cleomis* Ckll. ♂, *Clisodon terminalis* Cress., and *Megachile fortis* Cress. The flowers are also visited by Bombus, as I have recorded elsewhere (*Annals and Magazine Natural History*, November, 1899), and Townsend took a single male *Melissodes montana* Cress. He also took a butterfly, *Epargyreus tityrus* Fabr., not hitherto recorded from New Mexico. These results accord fairly well with those of Loew, who observed the insect visitors of Monarda in the Botanic Garden at Berlin.

	Bombus.	Other long-tongued bees.	Short-tongued bees.	Butterflies.
M. stricta, New Mexico	9	5	0	1
M. spp., Berlin	2	2	1	2

Both lists are doubtless very incomplete.

(3) *Rhus glabra* L. A widely distributed shrub, with conspicuous panicles of greenish flowers. The visitors might be expected to be much like those of the Umbelliferæ, but Townsend actually obtained a number of bees: *Bombus sonorus* Say, *B. prunellæ* Ckll., *Colletes gilensis* Ckll. ♂, *Coelioxys gilensis* Ckll., *Heriades gracilior* Ckll., *Colletes americana* Cress. ♂. He also obtained a butterfly, *Basilarchia weidemeyerii* Edw. In Europe Müller found the honeybee abundant on the allied *Rhus hirta*. In Illinois Robertson found fifty-eight species of insects on *R. glabra*, of which nineteen were bees, mostly short-tongued.

(4) *Potentilla thurberi* Gray. This is a beautiful species, differing from the ordinary species of the genus by its dark crimson flowers, on which Townsend took the following: *Megachile fortis* Cr., *Colletes gilensis* Ckll. ♂, *Vespa occidentalis* Cr.

(5) *Geranium atropurpureum* Heller. A common New Mexico plant, only recently recognized as distinct. Visited by males of *Colletes gilensis* Ckll., a short-tongued bee.

(6) *Heliopsis scabra* Dunal. Visited by *Megachile fortis* Cr., *Anthidium perpictum* Ckll., *Megachile fidelis* Cr., — all long-tongued bees. From *H. helianthoides*, in Illinois, Robertson collected twenty-two bees, fourteen being long-tongued.

A few other miscellaneous observations are to be recorded: *Anthophora cleomis*, ♂, at *Prunella vulgaris*, and ♀ at *Verbascum thapsus*; *Clisodon terminalis* at *Prunella vulgaris* and *Verbascum thapsus*; *Halictus angustior* at *Erysimum asperum*; *Melissodes ruidosensis* at *Erigeron macranthus*; *Vespa diabolica* at *Solidago trinervata* and *Sicyos parviflorus*; *Andrena barberi* at *Solidago trinervata*.

La Cueva, Organ Mountains.

This locality, also in southern New Mexico, is at the eastern side of the Mesilla valley, and has an altitude of about 5000 feet. The records given below are based on collections by Prof. C. H. T. Townsend:

(1) *Datura meteloides* DC. A magnificent species, with large, heavily scented white flowers. Although no doubt properly a sphinx-moth flower, it was visited by the following bees: *Xylocopa arizonensis* Cr., *Caupolicana yarrowi* Cr., *Anthophora montana* Cr., *Agapostemon viridulus* Fabr. (new to New Mexico). *Augochlora neglectula* Ckll. The Caupolicana flies early in the morning, before sunrise. According to Mr. Friese (*in litt.*) the Chilian *C. curvipes* Friese (♂) agrees with *C. yarrowi*.

(2) *Lippia wrightii* Gray (Verbenaceæ). A shrubby plant, characteristic of the region. Visited by *Xylocopa arizonensis* Cr., *Caupolicana yarrowi* Cr., *Anthophora montana* Cr., *Perdita albovittata* Ckll. (1 ♀), *Augochlora neglectula* Ckll., *Synhalonia crenulaticornis* Ckll. var. ♂ (clypeus yellow except the hind border broadly). — all bees, five long-tongued.

(3) *Tourerea multiflora* (Nutt.) Visited by bees: *Perdita mentzeliarum* Ckll. and *Anthophora californica* Cr. I learn from Dr. Rydberg that Tourerea, Eaton and Wright, takes the place of Hesperaster: the combination here given will be credited to him.

(4) *Phacelia congesta* Hooker. Visited by bees: *Ceratina nanula* Ckll. (3 ♀, 1 ♂), *Halictus ruidosensis* Ckll. (1 ♀), *Perdita phaceliæ* Ckll. These are all small bees.

Other observations are: *Nomada gutierreziæ* Ckll., on *Verbesina encelioides*; *Nomia foxi* D.T. and *Exomalopsis solani* Ckll., on *Solanum elæagnifolium*; *Augochlora neglectula* Ckll., at *Parthenium incanum*.

ROMEROVILLE.

A locality about six miles from Las Vegas. In *Entomological News*, 1901, p. 40, five insects are recorded from Ribes, *sp.* at this place. It can now be stated that the Ribes is *R. leptanthum veganum* Ckll. (*Proceedings of the Biological Society of Washington*, 1902, p. 99).

LAS VEGAS.

(1) *Asclepias verticillata* L. This is very attractive to flies; the following were taken from its flowers: *Syritta pipiens* L. (July 3, N. Stern), *Eristalis latifrons* Loew (July 3, M. Winters), *Echinomyia algens* Wied. (July 21), *Peleteria tessellata* Fab. (July 21), *Myiophasia ænea* Wied. (July 21). *Lygæus reclivatus* Say is also common on the plant. Robertson collected 115 species of insects from this plant in Illinois.

(2) *Ribes longiflorum* Nutt. The yellow-flowered currant, common both wild and cultivated in the vicinity. On May 12 Loyola Dillon and Olive Barnes collected on the flowers four species of bees and one wasp: *Bombus nevadensis aztecus* Ckll. ♀, *Halictus coriaceus* Smith ♀, *H. armaticeps* Cr. ♀, *H. pruinosus* Rob. ♀, Odynerus, *sp.* On May 9 of last year a ♀ *Synhalonia frater*, Cr. var. (new to New Mexico), was taken at the flowers. This and the Bombus can probably get some nectar, but the Halicti only get pollen.

(3) *Anogra albicaulis* is a large white evening primrose, doubtless intended for moths, but on May 29 Eldon Tuttle and Leo Tipton discovered a minute new bee of the genus Perdita visiting its flowers at Las Vegas.

Perdita anogræ, n. sp., ♂. Length about $3\frac{1}{2}$ mm.; head and thorax very dark olive green; cheeks unarmed; face below antennæ all bright yellow except the clypeal dots, yellow not extending upwards in middle line, but at sides going a little above the antennæ and then terminating abruptly, just touching the facial foveæ, making slightly more than a right angle with the eye; eyes pale green, the lower half of the posterior orbital margin narrowly bordered with yellow: face and mesothorax not conspicuously hairy; antennæ pale orange, dark brown above as far as third joint of flagellum; vertex and mesothorax minutely sculptured, but rather shining; tubercles light yellow; pleura

all dark; tegulæ pale brownish, with a yellowish spot; wings rather small, hyaline, brilliantly iridescent; nervures and stigma sepia brown, third discoidal distinct; marginal cell obliquely truncate; second submarginal narrowed to a point above; legs brownish-orange, the femora black behind, tibiæ with a dark brown stripe on outer side, tarsi with at least the last joint darkened; abdomen rather broad, shining black, with transverse wedge-shaped bluish-white marks on the sides of segments two to four; ventral surface black.

In my table in *Bulletin of Laboratory of Denison University*, XI, this runs to section 30, where it is at once distinguished by its spotted abdomen. It is closely allied to *P. sexmaculata*, agreeing in the ornamentation of the face and color of the antennæ, but the color of the abdominal spots is entirely different, as also is the shape of the second submarginal cell, and *P. anogræ* is a smaller insect than *sexmaculata*.

(4) *Verbena bipinnatifida* Nutt. is a plant with umbel-like heads of brilliant purple flowers, allied to the Verbena of gardens, and adapted to butterflies. On June 7 I saw it visited by the butterfly *Pyrameis cardui* and the day-flying hawk moth *Deilephila lineata*; but to my surprise I also saw a female *Anthophora montana*, a long-tongued bee, sucking vigorously and apparently successfully. She had not collected any pollen.

(5) *Phlox nana* Nutt. A small species characteristic of our region, with brilliant pink flowers. It is adapted to butterflies, but on June 7 I saw a short-tongued bee, *Agapostemon texanus*, ♀, repeatedly trying to suck and of course getting nothing. Elias Nelson, in his revision of Phlox, says the corolla of *P. nana* is "red" or "white." It is always whitish beneath, but the upper surface is typically bright pink, varying, however, at Las Vegas to pale mauve (forma *lilacina*) and white with a large pink "eye" (forma *oculata*), the markings round the throat remaining the same in each case.

(6) *Sophora sericea* Nutt. is a plant allied to Astragalus, with conspicuous white flowers. It seems to be adapted to bumblebees, and is visited by *Bombus morrisoni*.

Engle.

Engle is a locality near the Rio Grande about fifty miles north of Las Cruces. Nothing has hitherto been known of its insect fauna.

Astragalus bigelovii Gray. One of the so-called "locoweeds" common in the southern part of New Mexico in open ground. The leaves are densely covered with white silky hairs.

Miss Nora Newberry, during the latter part of April and the first few days of May, collected from the flowers a number of long-tongued bees, which prove to be as follows :

(1) *Synhalonia lycii* Ckll., both sexes ; the male was not before known. In the male the clypeus, labrum, and a small, broadly triangular supraclypeal area are cream-color. (In the males of *S. edwardsii* and *frater* the clypeus is very bright yellow, and there is no supraclypeal mark.)

(2) *Anthophora affabilis* Cr. ♀. The identity of this has been confirmed by Mr. Fox, who compared it with Cresson's type. In the Mesilla valley it visits *Lycium torreyi*.

(3) *Anthophora porteræ* Ckll. Several females; only two specimens of this species were previously known. It is readily distinguished from *A. affabilis* by the black hair mixed with the light on the mesothorax. The female nearly agrees with the description of *A. ignava* Cr., but Mr. Fox has kindly compared it with Cresson's type, and assures me that it is different. Mr. Fox remarks that the female seems to agree with *A. edwardsii* Cr., except that it is larger; the male, however, has not the tooth on inner side of hind joint of posterior tarsi, and the lateral face-marks are not "lanceolate," but are shaped like a rose-thorn. A male *A. porteræ* was taken at flowers of *Ribes longiflorum*, at Las Vegas, N.M., May 15, 1902, by Eldon Tuttle and Leo Tipton. It differs from the original type in having more yellow on the scape and rather more black hair on the mesothorax. A character overlooked in the original description is a little pencil of black hair overlapping the upper anterior corner of each eye.

It is to be noted that both Synhalonia and Anthophora visit Ribes, Lycium, and Astragalus, plants of very different affinities but similar in their adaptation to long-tongued bees

TROUT SPRING.

This is a locality in Gallinas Cañon, N.M., some miles above Las Vegas Hot Springs. It is of interest on account of the mixed boreal and austral elements in its fauna and flora, the result in large measure, no doubt, of the narrowness of the cañon, whereby some slopes get little or no sun, while others are well warmed. The abundance of *Pinus scopulorum* and *Populus angustifolia* indicate the Transition Zone, while *Heracleum lanatum*, *Dasiphora fruticosa*, and *Ribes irriguum* are

distinctly Canadian Zone types. A fine bush of the last mentioned grew on the north side of a huge rock, shaded from the sun. An Upper Austral representative is *Ribes longiflorum* (a variety, however, with the petals deep red, the calyx tube often reddish outside, the flowers about 14 mm. long, and the apex of the leaves obtuse, thus closely approaching the northern *R. aureum*, as restricted by Coville), while at its flowers we found the typically southern butterfly *Epargyreus tityrus* Fabr., which extends to South America and the West Indies. The bright yellow flowers of the Canadian Zone Thermopsis were visited by a female *Megachile wootoni* Ckll., a bee of a strictly alpine and boreal type. A magpie (*Pica pica hudsonica*) was also to be regarded as a boreal representative. The pink flowers of the Upper Austral and Transition *Phlox nana* were seen in the cañon a short distance below Trout Spring.[1]

The insect visitors of one species of plant were rather carefully studied by my wife and myself, May 24, 1902.

Iris missouriensis Nutt. Visited by bees, butterflies, and flies. The bees crawl in under the petaloid divisions of the style, and so doubtless effect cross fertilization. The butterflies and flies (Bombyliidæ) suck from between the perianth segments, and appear to get their meal without paying for it.

The following insects were observed:

(1) *Colias eurytheme* ♀, Lycæna, Thanaos, — all butterflies, sucking.

(2) *Bombylius major* L., with proboscis 8–8½ mm. long, very abundant, sucking. In Europe a syrphid (Rhingia) with a proboscis 11 mm. long visits *Iris pseudacorus*, as is described by Müller.

The remaining species are bees:

(3) *Megachile wootoni* Ckll., *Megachile latimanus* Say. A male of each found sitting on the flowers, perhaps waiting for the females.

(4) *Synhalonia frater* Cresson. One of each sex.

(5) *Anthophora bomboides neomexicana* Ckll. One ♂.

(6) *Halictus coriaceus* Smith. One ♀.

[1] Mr. Eldon Tuttle lately found in Las Vegas a flower of *Phlox nana* with the limb 8-parted, a character which, if not aberrational, would take it out of the Polemoniaceæ. I have since found a flower with the limb 7-parted.

(7) *Augochlora confusa* Rob. Two ♀. These differ from a specimen received from Mr. Robertson in having the basal area of metathorax bounded by a sharp rim, but Robertson's description indicates that such specimens occur also in Illinois. The species is new to New Mexico.

(8) *Osmia pusilla* Cresson, one ♂; Osmia, two new species, males. I have sent these to Mr. Titus, who is revising the genus.

LAS VEGAS HOT SPRINGS.

Verbena macdougalii was visited July 11 by bombyliid flies, *Systoechus vulgaris* Lw. (det. Coq.), as observed by Miss M. Holzman.

Ribes cereum Dougl. was visited May 24 by *Bombus juxtus* Cresson.

I will take this opportunity to record from Las Vegas Hot Springs the dragon fly *Hyponeura lugens* Hagen. Prof. J. A. Needham, who kindly identified it, states that the genus is new to the United States, but there are specimens from Arizona in the Cornell University collection, not hitherto recorded.

APPENDIX.

Two New Species of Osmia.

The two new species of Osmia collected on flowers of Iris at Trout Spring, N.M., were sent to Mr. Titus with the expectation that they might prove identical with species which he had already described in MS. As this is not the case, they are briefly diagnosed below. Some additional notes and comments will be given by Mr. Titus when he publishes his revision of the American species of Osmia.

Osmia iridis Cockerell and Titus, *n. sp.*

♂. Length 9 mm., stout; head and thorax yellowish-green; abdomen dark blue-green; antennæ long, slender, entirely black, subtruncate at apex; pubescence of head and thorax abundant, erect, white; vertex very broad; mandibles entirely black; legs black, with black hair (white on first four femora), hind femora slightly bluish; abdomen short and broad, with white hair on first segment, on the others mixed black and white; sixth segment reflexed, entire. Hind tibial spurs black, strongly

curved at tips; eyes perfectly black; cheeks and sides of vertex with some long black hairs mixed with the pale; tegulæ black, with a slight green tinge; wings slightly dusky, nervures black; second submarginal cell long; anterior edge of clypeus nodulose; clypeus and front as densely punctured as is possible. Mr. Titus adds: "A very distinct species; apical margin of second ventral segment is different from any species heretofore seen. The antennæ are crenulated slightly beneath, and this gives them slight resemblance to males of *lignaria* section, but the species does not belong there. It would be well to note the hairiness of the labial palpal joints 1 and 2."

Osmia chlorops Cockerell and Titus, *n. sp.*

♂. Length about 10 mm., brassy green, with bluish tints on abdomen and thorax; the abdomen shining, the head and thorax densely punctured; pubescence white, long and abundant on face; legs strongly tinged with green. Head large, face almost golden; eyes (in life) green, black anteriorly; mandibles black; antennæ long, black, crenulated; first joint of flagellum covered with a seal-brown velvety pile; tegulæ with greenish punctured margins; wings somewhat dusky; hind tarsi with the basal joint broadened distally, and covered on the inner side with short brown-black hair; hind tibial spurs black, curved at tips; sixth dorsal segment of abdomen notched; apical segment deeply and broadly notched; third ventral segment deeply and broadly emarginate, the edges of the emargination fringed with short shining hairs.

NOTES AND LITERATURE.

ZOÖLOGY.

Gardiner's "Maldive and Laccadive Archipelagoes," Part II.[1] — This second part contains ten "reports." The first, by F. F. Laidlaw, deals with the Amphibia and Reptilia. All but one of the species are abundant in Ceylon, and the exception, *Lygosoma albopunctatum*, is a lizard that is widespread in the Oriental region. For most of the species the region in question is near the western limit of its area of distribution. Only two Amphibia are listed, a Rana and a Bufo; four lizards, two Hemidactyli, a Calotes, and the Lygosoma; four snakes; one species of Testudinidæ (Nicoria) and two marine turtles (Chelone).

The Lepidoptera are listed by E. Meyrick. There are sixty-seven species, of which practically all occur also in India or Ceylon. A single species of Notarcha, regarded as new, replaces the widespread *N. multilinealis*.

Mr. A. E. Shipley has enumerated the six species of Echiurodea and nineteen sipunculoidea. The former belong to the genera Bonellia and Thalassema, characteristic of the warm and temperate seas. A new genus of sipunculids, Lithacrosiphon, allied to Aspidosiphon, is described and figured.

The land and fresh-water mollusks are treated by E. A. Smith. He says: "The present collection comprises eight land and two fresh-water forms from the Maldives, and four terrestrial species from the Laccadives, three of which are included among those from the Maldives. The latter group, judging from the collection at hand, does not possess a single indigenous species, all the forms occurring either on the Indian peninsula or in Ceylon or other localities. As many plants are introduced into the islands by foreign vessels, some or all of the Mollusks there may be accounted for by importation. The list includes *Succinea vitrea*, known elsewhere only from Calcutta and Bombay; a new species, *Sitala vagata*, probably

[1] *The Fauna and Geography of the Maldive and Laccadive Archipelagoes*, etc. Edited by J. Stanley Gardiner. Cambridge, University Press, 1902. Vol. i, pt. ii, pp. vi, 119–222, Pls. VI–XIII, Figs. 24–40.

from India; *Euplecta indica*, var. *malabarica*, found on the adjacent Malabar coast; *Xestina bombayana*, agreeing "in all respects with those from the mainland of India"; *Rhachis punctatus* and *Opeas gracilis*, which are resistant forms associated with plants, with which they may be transported; *Tornatellina manilensis; Melampus castaneus*, from the shore, a wide ranging species; *Leptopomoides halophilus; Melania tuberculata*, found from Syria to Australia and West Africa; and *Cyrena ceylonica*, of mangrove swamps.

The pigments of corals have been investigated by Dr. MacMunn, who finds them "either chlorophylloid or of a closely connected kind of pigment, which latter absorbs the violet end of the spectrum and seems generally changeable into the next kind by the agency of heat, etc., namely, into the dark pigment which gives the coral its dark color in the fresh condition."

The sixteen species of Chætognatha are treated by L. Doncaster. In his consideration of the variation and distribution of the group he makes many interesting points. He lays stress on the fact that since closely allied species are found living together without barrier of habitat, they can hardly have arisen through natural selection; [but it must not be forgotten that there are others than *spacial* barriers]. Remarkable is the occurrence here of a species (*Sagitta flaccida*) previously described only by Conant from the Bahamas.

The six dragon flies are listed by F. F. Laidlaw. One seems to be new, the others are well known Ceylon and Indian species, or have a wider distribution.

The first installment of a series of papers on marine crustaceans is given by L. A. Borradaile. He here considers the Portunidæ, a family that "is highly variable and varietal [exhibiting varieties] and is probably undergoing rapid evolution in many directions." The account of each species is accompanied by valuable notes on its variation.

The longest contribution is by Gardiner, continuing his account of the coral formation of the islands. It is clear and interesting. He assumes, first of all, the former existence of a continent connecting India and Madagascar, which underwent subsidence, leaving certain elevations where mountain peaks were. The archipelagoes occupy the position of one or two of these mountains. Second, the mountains became eroded by the action of oceanic currents to nearly level plateaux two hundred fathoms below the surface. Third, upon these plateaux there began to grow *deep sea* corals, assisted by nullipores and other organisms. By growing on the skeletons of their ancestors

these corals formed banks up to forty or fifty fathoms, at which height the true reef-building corals were able to attach themselves. In time they gained the supremacy and built up the reef to near the surface. A lagoon was formed in the center of the reef partly by the more rapid growth of the organisms on the edge of the bank and partly by the subsequent solution of the central parts. This article is well illustrated by charts and diagrams. C. B. D.

Jordan and Heath's "Animal Forms."[1] — This "second book of zoölogy" is the companion volume of the already well-known *Animal Life* by Jordan and Kellogg, and the two books may be obtained separately or bound together in one volume with the title *Animals.* Whereas the first volume, *Animal Life*, dealt with animal ecology, the second book gives an elementary account of animal morphology. The introductory chapters deal with the differences between animals and plants, the characteristics of an animal as exemplified by a mammal, and the cell and protoplasm. Then follows an examination of typical representatives of the great groups, from the simplest to the most complex. While animals are here considered primarily from the morphological viewpoint, considerable attention is given to functions of organs and to habits and life histories.

Animal Life was designed for the first half year in zoölogy in the high school, and *Animal Forms* to complete a full year's work. However, *Animal Forms* may be used alone or as the first book.

With regard to the adaptability of the book to the conditions obtaining in secondary schools, *Animal Forms* and its companion volume are unquestionably the best existing books for supplementary reading for the high-school beginners; but as a *basis* for an elementary course they are far from practicable, for it will be difficult to follow either book in close correlation with laboratory study. In spite of the authors' emphasis upon "a basis of observation," there has already been manifested in the use of *Animal Life* in some schools a tendency to drift backward towards the old-time recitation method. The informational side of zoölogical teaching must not be allowed to displace scientific training, and a definite laboratory course, and not a text-book, must give the foundation, to which may be added supplemental and closely correlated reading. As sources for such collateral information from which high-school teachers may select topics relating to the laboratory study, *Animal Forms* and *Animal*

[1] Jordan, David Starr, and Heath, Harold. New York, Appleton, 1902. 8vo, vi + 258 pp., 140 figs.

Life deserve the highest commendation, and every pupil in elementary zoölogy should be made familiar with them.

A laboratory manual to accompany *Animal Forms* is announced as in preparation. This perhaps will throw some light upon the problem of correlation between laboratory work and the use of the text.

Aside from the secondary schools, where undoubtedly the books will have the greatest sale, the combined volume, *Animals*, will offer a mine of information and inspiration to college students who use it for collateral reading. Moreover, it should be especially recommended to the growing body of readers who eagerly seek general books relating to animal life.

M. A. B.

BOTANY.

Notes. — Late numbers of the *Botanical Gazette* contain a descriptive list of the plants collected by Dr. F. E. Blaisdell at Nome City, Alaska, prepared by Miss Eastwood. One hundred and seventy species are recorded, several of them considered as new to science.

In the *Bulletin of the Torrey Club* for February Miss Eastwood describes and figures a number of new Californian anthophytes.

Dr. Rydberg's "Studies on the Rocky Mountain Flora," VII, in the March *Bulletin of the Torrey Club*, contains a number of new Ranunculaceæ, Papaveraceæ, and Fumariaceæ.

In No. 4 of the current volume of *Transactions of the Academy of Science of St. Louis*, Professor Norton discusses the unexplored botanical regions of the Southwest, and describes and figures a number of new spermatophytes.

Several southwestern plants are named by Cockerell in *Torreya* for March.

Several new species of trees from the Eastern and Southern States are described by Ashe in the March number of the *Botanical Gazette*.

Fifty additions to the "Catalogue of Ohio Plants" are made by Kellerman in the *Ohio Naturalist* for December last.

A list of the climbing plants of Ohio is published by Miss Dufour in the *Ohio Naturalist* for February.

Dr. Harshberger gives an account of a botanical ascent of Mt. Katahdin, Maine, in the *Plant World* for February. The article is illustrated by half tones and zonal diagrams.

In Vol. LIII, Part III, of the *Proceedings of the Academy of Natural Sciences of Philadelphia*, Dr. Harshberger has an illustrated paper on the ecology of the San Domingo flora.

Vol. XX of the *Acta Horti Petropolitani* consists of the first part of a "Flora Manshuriæ" by V. L. Komarov, occupied with about one hundred pages of bibliography and discussion, in Russian, followed by the pteridophytes and monocotyledons as far as the Orchidaceæ.

Hemsley and Pearson publish, in No. 224 of the *Journal of the Linnean Society* (Botany), an account of what is known of the flora of Tibet.

A paper by Willis and Gardiner, on the botany of the Maldive Islands, is published in Vol. I, Part II, of the *Annals of the Royal Botanic Gardens, Peradeniya.*

In the opening number of the current volume of *Nyt Magazin for Naturvidenskaberne*, Prof. N. Wille contrasts the present vegetation of the Norwegian district of Telemarken with the records for the same district published by H. J. Wille in 1786.

A very interesting detailed study of rheotropism, by Professor Newcombe, presented at the Chicago meetings of last winter, has been published in the *Botanical Gazette.*

Mendel's laws of inheritance in hybrids and crossbreeds are discussed by Weldon in *Biometrika* for January, and by Correns in Heft 3 of the current volume of *Berichte der deutschen botanischen Gesellschaft.*

An illustrated article on caprification as practiced in Algeria, appears in the January number of the *Revue horticole de l'Algérie.*

The self-pruning of plants forms the subject of an article by Schaffner in the *Ohio Naturalist* for January.

Photosynthesis is being passed in review by André Richter in current numbers of the *Revue générale de botanique.*

A portrait of the Spanish botanist Colmeiro, with biography, is published by Lázaro e Ibiza in Vol. XXX of the *Anales de la Sociedad Española de Historia Natural.*

A portrait of Alvah A. Eaton forms the frontispiece to the April number of the *Fern Bulletin.*

A portrait of von Heldreich appears on the first page of the *Deutsche botanische Monatsschrift* for March.

Livraison 2 of the current volume of the *Bulletin du Jardin impériale de St.-Pétersbourg* contains a portrait of the late Dr. J. Klinge.

In the double number (149–150) of the *Bulletin de l'Académie Internationale de Géographie Botanique* is published an excellent portrait of the veteran Chilian botanist, R. A. Philippi, accompanied by a list of his publications, numbering two hundred and twenty-six entries.

A short biographical sketch of Schweinitz, with portrait, is published by Mr. Shear in the *Plant World* for March.

Vol. II of Radde's *Die Sammlungen des kaukasischen Museums*, published in Tiflis, contains twelve portraits and a considerable number of plates and maps.

Lamarck's herbarium forms the subject of an article by Bonnet in the *Journal de botanique* for April.

Dr. Harshberger has an article on the botanical gardens of Jamaica, in the *Plant World* for March.

Vegetable pathology, and the method of teaching it as practiced in St. Louis, are discussed by Dr. von Schrenk, of the Shaw School of Botany, in the *Bulletin of the Torrey Botanical Club* for February.

Professor Marshall-Ward considers predisposition and immunity, in plant diseases, in Vol. XI, Part V, of the *Proceedings of the Cambridge Philosophical Society*.

In the labels for his exsiccatæ of Ohio fungi, reprinted in current numbers of the *Ohio Naturalist*, Professor Kellerman gives transcripts of the original descriptions of the species.

Kellerman and Jennings, in the *Ohio Naturalist* for April, give details of experiments to test the comparative susceptibility of maize and sorghum to Cintractia when taken from different hosts.

Fusarium Lini and the "flax-wilt" that it causes are the subject of *Bulletin No. 50* of the North Dakota Experiment Station.

Papers on fungi, by Peck, Salmon, and Long, are published in the *Bulletin of the Torrey Botanical Club* for February.

The ascomycetous genera Urnula and Geopyxis are considered by Miss Kupfer in the *Bulletin of the Torrey Botanical Club* for March.

Current numbers of *Torreya* contain keys to the species of a number of genera of agarics, by Earle.

The *Botanical Gazette* for July contains the following articles: Arthur, "Uredineæ occurring upon Phragmites, Spartina, and Arundinaria in America"; Nelson, "Contributions from the Rocky

Mountain Herbarium," III; Atkinson, "Three New Genera of the Higher Fungi"; Berry, "Notes on the Phylogeny of Liriodendron"; Cook, "Polyembryony in Ginkgo"; von Schrenk, "Root Rot of Apple Trees caused by *Thelephora Galactina*"; and Wilcox, "*Stipa Hassei* not a good species."

The *Bulletin of the Torrey Botanical Club* for June contains the following articles: Kirkwood and Gies, "Chemical Studies of the Cocoanut, with some Notes on the Changes during Germination"; Curtis, "Some Observations on Transpiration"; Peirce, "Forcible Discharge of the Antherozoids in *Asterella Californica*"; Harper, "*Taxodium distichum* and Related Species, with Notes on some Geological Factors influencing their Distribution"; Nelson, "New Plants from Wyoming," XIV; Wight, "The Genus Eritrichum in North America."

The *Annals of Botany* for June contains the following articles: Yapp, "Two Malayan 'Myrmecophilous' Ferns"; Ward, "On the Relations between Host and Parasite in the Bromes and their Brown Rust, *Puccinia dispersa*"; Hill, "On Variation in the Flowers of Certain Species of Primula"; Copeland, "The Mechanism of Stomata"; Thiselton-Dyer, "Morphological Notes," VII; Farmer and Hill, "On the Arrangement and Structure of the Vascular Strands in *Angiopteris evecta* and some other Marattiaceæ"; and Fritsch, "Algological Notes."

Vol. XXIII of the *Transactions of the American Microscopical Society*, issued in May, contains the following botanical articles: Jackson, "A New Species of Crenothrix (*C. manganifera*)"; and Bessey, "Structure and Classification of the Conjugatæ, with a Revision of the Families and a Rearrangement of the North American Genera."

Heft 9 of Engler's *Das Pflanzenreich*, a volume of 438 pages, with numerous figures, is a revision of Myrsinaceæ by Mez, and bears date May 6, 1902.

A revision of Conocephalus, by Bargagli-Petrucci, is a prominent feature of the *Nuovo Giornale Botanico Italiano* for April.

A revision of the Podostemaceæ of India and Ceylon, by Willis, appears in Part III of the *Annals of the Royal Botanic Gardens, Peradeniya*, issued in May.

The laws of plant distribution in alpine regions are analyzed by Jaccard in *Flora* of April 30.

An interesting addition to the botany of the Atlantic islands is a comparative account of the mosses of the Azores, Madeira, and the

Canaries, published, in connection with an article on some mosses of the latter islands, by Cardot, in No. 5 of the *Bulletin de l'Herbier Boissier* for the present year.

No. 10 of Marcus E. Jones's *Contributions to Western Botany*, issued as an individual publication by the author from the Mammoth Record Print of Robinson, Utah, under date of June 1, 1902, contains a revision of the Alliums of the Great Basin region, with notes on the markings of the bulbs and a key to the species based on them; further notes on Astragalus; a study of the Nyctaginaceæ, chiefly of the region of the Great Plateau; and descriptive or synonymic notes on a number of miscellaneous species.

The flora of Scott and Muscatine counties, Iowa, is the subject of a paper by Barnes, Reppert, and Miller, in the recently issued eighth volume of *Proceedings of the Davenport Academy of Sciences.*

A botanical series of the *University of California Publications* begins with the issuance, under date of June 7, of a paper by H. M. Hall, entitled "A Botanical Survey of San Jacinto Mountain." It appears to be a well done piece of work, on the prevalent ecological lines, and is well illustrated.

A catalogue of British marine algæ, by Batters, is in course of publication as a supplement to current numbers of the *Journal of Botany.*

A large part of Vol. III, fasc. 3-6, of *Le Botaniste*, dated June 10, is occupied by a paper on Euglenia, by Dangeard.

Cladophora, as represented in the salt water of New England, — a difficult group, — is revised by Collins, in *Rhodora* for June.

Studies of spore germination in the common mushroom and other agarics, by Miss Ferguson, form *Bulletin No. 16* of the Bureau of Plant Industry of the national Department of Agriculture.

The Geastreæ of the United States are revised in an illustrated paper by C. G. Lloyd, forming *Bulletin No. 5* (mycological series, No. 2) of the Lloyd Library.

In the *Journal of Botany* for June, Arthur Lister describes and figures a Chondrioderma, — *C. asteroides*, — which in aspect resembles to a marked degree a small Geaster.

The *Technology Quarterly* for June contains an article by Whipple on the physical properties of gelatin, with reference to its use in culture-media.

A paper on albino phenomena in the vegetable kingdom, by Pantanelli, is published in Nos. 10-12 of Vol. XV of *Malpighia.*

An account of double fertilization in *Monotropa uniflora* is published by Shibata in *Flora* of December 4 last.

In the *Journal de Botanique* for May, Guignard has an article on double fertilization in Solanaceæ.

The mechanism of secretion of extra-floral nectaries is the subject of an article by Haupt in *Flora*, Vol. XC, Heft 1, which also contains a paper by Lepeschkin on the significance of the water-secreting organs of plants.

Meierhofer has a well illustrated article on the bladders of Utricularia in *Flora* of Dec. 4, 1901, which also contains a paper by Brenner on climate and leaf form in Quercus, and an extensive study of Gunnera by Schnegg.

An account of the developmental history of Quercus is given by Brenner in Vol. XC, Heft 3, of *Flora.*

An important addition to the literature of plant physiology, in its economic bearings, is Dr. Whitten's thesis on "Das Verhältnis der Farbe zur Tötung von Pfirsichknospen durch Winterfrost," recently published in Halle.

A handbook of the economic plant products of Ceylon, by Willis and Wright, is in course of publication as supplements to current numbers of the *Annals* of the Peradeniya garden.

An interesting account of the fiber Agaves, by Marshall, is reprinted from the *Journal of Geography* in the *American Journal of Pharmacy* for July.

An illustrated account of the new botanical laboratories at Liverpool is contained in *Nature* for June 12.

Several views of the Cape Town Municipal Gardens are published in the *Gardeners' Chronicle* of June 7.

A portrait of J. B. Ellis forms the frontispiece of No. 62 of the *Journal of Mycology.*

A memorial of the Italian botanist Gibelli is separately issued from Vol. XIV of *Malpighia.*

A biographic sketch of Ramírez, with portrait, is published in the *Memorias y revista de la Sociedad Cientifica "Antonio Alzate"* of October last.

In *Biometrika* for April, Mr. Yule has a paper on the variation of the number of sepals in *Anemone nemorosa*, and Mr. Tower a paper on the variation in the ray flowers of *Chrysanthemum leucanthemum*, on which subject is added a further note by Pearson and Yule.

An editorial in the same number of *Biometrika* contains some desirable cautions as to the polymorphism of certain species which appears to result from the frequency polygons derived from tabulated individual measurements.

The first fascicle of Vol. III of the *Contribuzioni alla biologia vegetale* of the *R. Istituto botanico di Palermo* contains the following papers of general interest: Terracciano, "Contributo alla biologia della propagazione agamica nelle fanerogame"; Albo, "Sul significato fisiologico della nicotina nelle piante di tabacco"; La Floresta, "Formazione di radici avventizie nelle foglie di *Gasteria acinacifolia*"; Borzí, "Anatomia dell' apparato senso-motore dei cirri delle Cucurbitacee"; and La Floresta, "Struttura ed accrescimento secondario del fusto di Xanthorrhoea." The articles are well illustrated and a French résumé is given of their contents.

Rhodora for June contains the following articles: Collins, "Marine Cladophoras of New England"; Nye, H. A., "Blooming of Hepaticas"; Brainerd, "Two more Rare Plants from Lake St. John, Quebec"; Blanchard, "Some Vermont and New Hampshire Plants in the Middle Connecticut Valley," I; Fernald, "The Seneca Snakeroot in Maine"; Webster, "*Clathrus columnatus* in Lawrence, Mass."; Robinson, "Two New Hypericums of the Adpressum Group"; and Fernald, "An Anomalous Skullcap."

The third *Report of the Michigan Academy of Science* contains the following botanical articles: Pollock, "Relation of the Fibro-Vascular Bundles in the Root and Hypocotyl in *Echinocystis lobata*"; Reed, "Ecology of a Glacial Lake"; Larsen, "Disease of the White Birch"; Denton, "Interfoliar Scales of Monocotyledonous Aquatics"; Clark, "Notes on the Flora of Eaton County"; Davis, "Notes on *Utricularia cornuta*"; Davis, "Wolffia Notes"; Longyear, "Notes on Michigan Saprophytic Fungi"; Longyear, "New Species of Michigan Fungi"; Longyear, "Sclerotium Disease of the Huckleberry"; and Conover, "*Asparagus plumosus*."

The *Botanical Gazette* for May contains the following articles: Miyaké, "On the Starch of Evergreen Leaves and its Relation to Photosynthesis during the Winter"; Newcombe, "Rheotropism of Roots" (conclusion); Overton, "Parthenogenesis in *Thalictrum purpurascens*"; Leavitt, "Subterranean Plants of Epiphegus"; Fairchild, "Notes of Travel," VIII; Cockerell, "A New Heliotropium (*H. xerophilum*)."

The *Botanical Gazette* for June contains the following articles: Rimbach, "Physiological Observations on the Subterranean Organs of some Californian Liliaceæ"; Smith, "The Parasitism of *Botrytis cinerea*"; Shaw, "The Development of Vegetation in the Morainal Depressions of the Vicinity of Woods Hole"; Webb, "A Morphological Study of the Flower and Embryo of Spiræa"; Fairchild, D. G., "A Precocious Poplar Branch"; and Wilcox, "Numerical Variation of the Ray Flowers of Compositæ."

Botanical papers in No. 7 of the *Bulletin of the New York Botanical Garden* are: Earle, "Mycological Studies," I; Williams, "A Preliminary List of Montana Mosses"; and Hollick, "Geological and Botanical Notes, Cape Cod and Chappaquidick Island, Mass."

Torreya for June contains the following botanical articles: Rydberg, "Our Yellow Lady's-Slippers"; Underwood, "The Bracket Fungi"; Lloyd, "An Interesting Irregularity in a Rose Flower"; and Britton, E. G., "Notes on a Long Island Moss."

The *Bulletin of the Torrey Botanical Club* for May is entirely occupied with Cryptogams, mostly fungi.

Botanical articles in the *Ohio Naturalist* for June are: Kellerman and Tyler, "Further Additions to the Catalogue of Ohio Plants"; Dresbach, "Moulds Injurious to Foods"; and Tyler, "Rosette Plants of Ohio."

A large part of Engler's *Botanische Jahrbücher* continues to be occupied with descriptions of African plants.

As usual with the *Journal of the Royal Horticultural Society*, the number for April contains several articles of general botanical interest.

After an intermission of eight years, the *Journal of Mycology* begins its eighth volume with No. 61, bearing date May, 1902.

The great multiplication of species in Cratægus is commented on by Professor Bessey in *Science* for May 16.

A paper by Knuth on the geographic distribution, adaptive structure, and classification of the species of Geranium, is published in Engler's *Botanische Jahrbücher* of May 2.

A monograph of the Senecios of North and Central America, by Dr. Greenman, is published as a contribution from the laboratory of the Berlin Garden, in the first Heft for the current year of Engler's *Botanische Jahrbücher.* Keys are given to the sections, under each of which are enumerated the species recognized as belonging to it.

Dr. Holm has an article on the grass genus Arctophila Rupr. in the *Ottawa Naturalist* for June. Three new species are described.

An analytical key to the ferns of the northeastern states, based on stipe characters, by C. E. Waters, is printed in the *Johns Hopkins University Circular* for June.

A lecture on the past, present, and future of vegetable pathology, by Dr. G. Mottareale, is reprinted from *Italia Orticola* for March to May.

In *Education* for February, Dr. Harshberger discusses the question as to what part of the varied things comprised in "botany" is of most worth.

In *Popular Science News* for June, G. W. Browning has an illustrated article on insect-catching plants, other than those that are carnivorous.

Spindle formation in Agave is the title of a cytological paper by Osterhout, published as No. 8 of the current volume of *Proceedings of the California Academy of Sciences.*

An interesting note on the formation of hair masses in the stomachs of goats that have fed on the fruits of the sweetbrier rose is published by Sir William Thiselton-Dyer in *Nature* for May 8.

A study of galls and the insects producing them, by M. T. Cook, appears in No. 7 of the *Ohio Naturalist*, and is separately printed as a bulletin of the University of Ohio.

Professor Brewer has distributed separates of an article on the relation of forestry to public health, from the *Proceedings of the Twenty-Ninth Meeting of the American Public Health Association.*

The decorative possibilities of some native climbers are shown by Professor Nelson in *Bulletin No. 50 of the Wyoming Experiment Station.*

The *Revue horticole* for June 1 contains an illustrated article on the botanic garden of St. Pierre before its destruction by the eruption of Mont Pelée.

An account of the botanico-geographic regions of North America, as exemplified in the new botanical garden at Dahlem-Steglitz, is given by Professor Engler in Appendix IX of the *Notizblatt des K. Botanischen Gartens und Museums zu Berlin*, dated May 15, 1902.

Several new or little known Southern California plants form the subject of a note by LeRoy Abrams in No. 6 of the current volume of the *Bulletin of the Southern California Academy of Sciences.*

Parts III and IV of Spegazzini's "Nova addenda ad floram Patagonicam," separately issued from the *Anales del Museo Nacional de Buenos Aires*, Vol. VII, bears date of April 16, and includes species numbered from 474 to 977 inclusive, — a considerable number of them being new.

Visitors to the beautiful little island of Capri, in the Gulf of Naples, will find help in a study of its flora in a tasteful little handbook by Cerio and Bellini, entitled *Flora dell' Isola di Capri*, published by Emilio Prass of Naples.

A portrait and biographical sketch of Dr. Adam Kuhn, first professor of botany in America and at the University of Pennsylvania, with an illustration of the genus Kuhnia, named in his honor, are published by Dr. Harshberger in the *Alumni Register*, of Philadelphia, for April.

A portrait of Sir George King, formerly director of the Calcutta Garden, is published in the *Gardeners' Chronicle* of May 11.

A note on Parkinson, with figure of the Parkinson statue in the palm house at Sefton Park, Liverpool, is printed in the *Gardeners' Chronicle* for May 17.

CORRESPONDENCE.

Editor of the American Naturalist:

Mr. Robertson's criticisms in the *American Naturalist* for July appear to be exceedingly captious and trivial. In my paper on the colors of flowers I say of the visitors of *Nymphæa advena*, "I have collected on the flowers in Maine four Diptera, two Coleoptera, and one small bee, *Halictus nelumbonis*, which confines its visits to this flower." So far as possible my remarks on the visits of insects to flowers are based on numerous observations I have made in the field. The above remark is true of this bee, so far as I have collected it, in this locality.

Again, as to the number of visitors to the Umbelliferæ. It is certainly true that several species are visited by more than two hundred insects, while others approach quite closely to this number. I still believe that when a more careful and extended study of these plants shall have been made, the number of visitors to many species will be found to exceed two hundred. The visitors to many umbelifers have, moreover, never been collected.

As regards the visits of beetles to dull yellow flowers, it certainly never occurred to me that there was anything in my paper which could lead any reader to believe that I considered the statement as new. I mentioned the later observations of Müller, and also those of Loew, Schultz, and Knuth, as well as one of my own, and added that it did not appear necessary to carry the illustrations further. In the brief reviews of the coloring of the different plant families which space renders possible, I am compelled to omit many observations both of my own and of others. Mr. Robertson tells us that he has also made some observations on this subject, and the real animus of his remarks seems to be that he has been hurt because no reference was made to these. Mr. Robertson was not long ago severely censured by a correspondent of the *Canadian Entomologist* for his loose way of naming supposed new species of bees based on single specimens or on trivial characters. Of his regard for the rights of others a single illustration will serve. In the *Transactions of the Academy of Science, St. Louis*, Vol. X, No. 2, p. 48, after describing *Andrena viciniformis*, which he calls a new species,

he adds, "This may be the same as *A. dunningii.*" A comparison of the two descriptions will leave little doubt that the species are identical. In renaming *A. dunningii* an injustice is done both to the author of this species and to the person in whose honor it was named. Again, in the *Canadian Entomologist*, Vol. XXXIII, No. 8, p. 231, he writes: "*Epeolus lectoides* n. sp. ♀. — Closely resembles *E. lectus* Cr., and may be the same." Described from one specimen. Additional instances might easily be given. An author who will publish such descriptions as these certainly shows little desire for the advancement of the interests of science.

JOHN H. LOVELL.

WALDOBORO, MAINE, August 11, 1902.

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(Regular exchanges are not included.)

BEDDARD, F. E. Mammalia. The Cambridge Natural History. Vol. x. 8vo, xii + 605 pp., 285 figs. $4.00. — BLAISDELL, A. F. Life and Health. A Text-Book on Physiology for High Schools, Academies, and Normal Schools. Boston, Ginn & Co., 1902. 8vo, vi + 346 pp., 110 figs. — DAVIS, W. M. Elementary Physical Geography. Boston, Ginn & Co., 1902. 8vo, xviii + 401 pp., 190 figs., 9 pls. — EMERTON, J. H. The Common Spiders of the United States. Boston, Ginn & Co., 1902. 8vo, xviii + 225 pp., 501 figs. $1.50. — GARDINER, J. S. The Fauna and Geography of the Maldive and Laccadive Archipelagoes, etc. Vol. i, pt. ii. pp. vi, 119–222, Pls. VI–XIII. — GILBERT, J. K., and BRIGHAM, A. P. An Introduction to Physical Geography. New York, Appleton, 1902. 8vo, xvi + 380 pp., 263 figs. — JORDAN, D. S., and EVERMANN, B. W. American Food and Game Fishes. A Popular Account of all the Species found in America North of the Equator, with Keys for Ready Identification, Life Histories, and Methods of Capture. New York, Doubleday, Page & Co., 1902. 8vo, l + 573 pp., colored plates, text figures, and photographs. $4.00. — JORDAN, D. S., and HEATH, H. Animal Farms. A Second Book of Zoölogy. New York, Appleton, 1902. 8vo, vii + 258 pp., 140 figs. — RABL, CARL. Die Entwicklung des Gesichtes. Tafeln zur Entwicklungsgeschichte der äusseren Körperform der Wirbelthiere. I. Heft, Das Gesicht der Säugethiere, I, (Kaninchen, Schwein, Mensch). Leipzig, Engelmann, 1902. vi + 21 pp. folio, 8 pls. 12 marks. — ROOSEVELT, THEO., VAN DYKE, T. S., ELLIOT, D. S., and STONE, A. G. The Deer Family. New York, Macmillan, 1902. 8vo, ix + 334 pp., 21 pls., 5 maps. $2.00. — SAGE, D., TOWNSEND, C. H., SMITH, H. M., and HARRIS, W. C. Salmon and Trout. New York, Macmillan, 1902. 8vo, x + 417 pp., 20 pls, 13 figs. — SANDYS, E., and VAN DYKE, T. S. Upland Game Birds. New York, Macmillan, 1902. 8vo, vii + 429 pp., 9 pls. — SMITH, EUGENE. The Home Aquarium and How to Care for It. A Guide to its Fishes, Other Animals, and Plants, etc. New York, Dutton, 1902. 8vo, ix + 213 pp., 137 figs. $1.20. — WHEELOCK, IRENE GROSVENOR. Nestlings of Forest and Marsh. Chicago, McClurg, 1902. 8vo, xvi + 257 pp., 22 pls., text figs.

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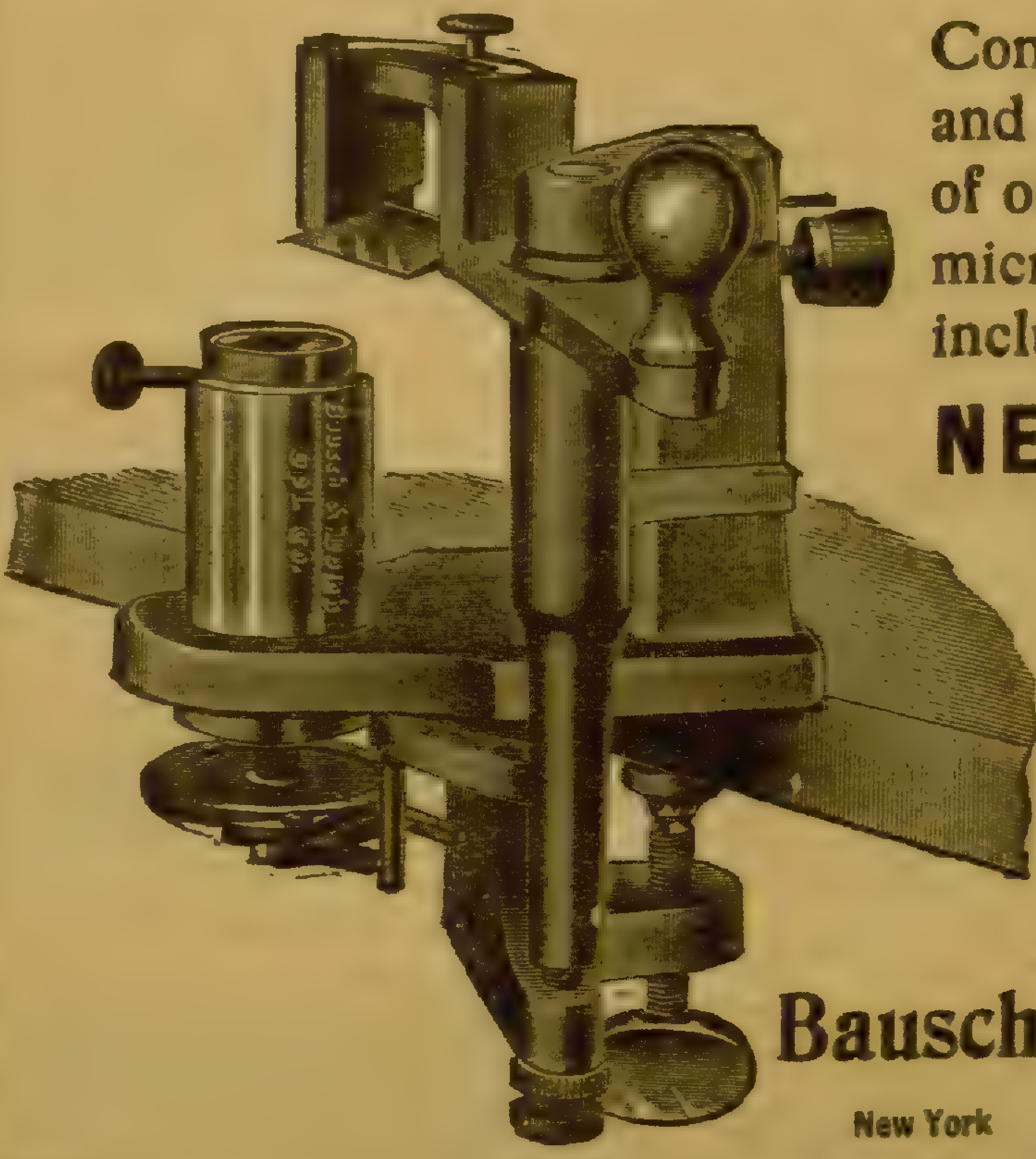

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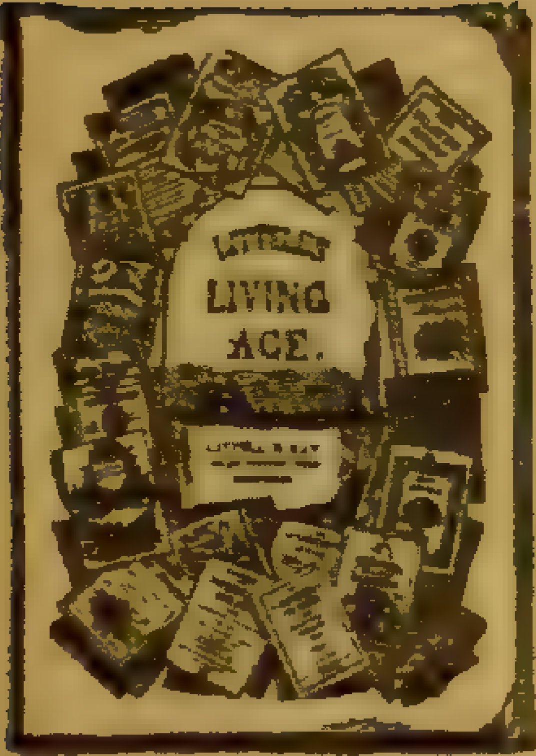

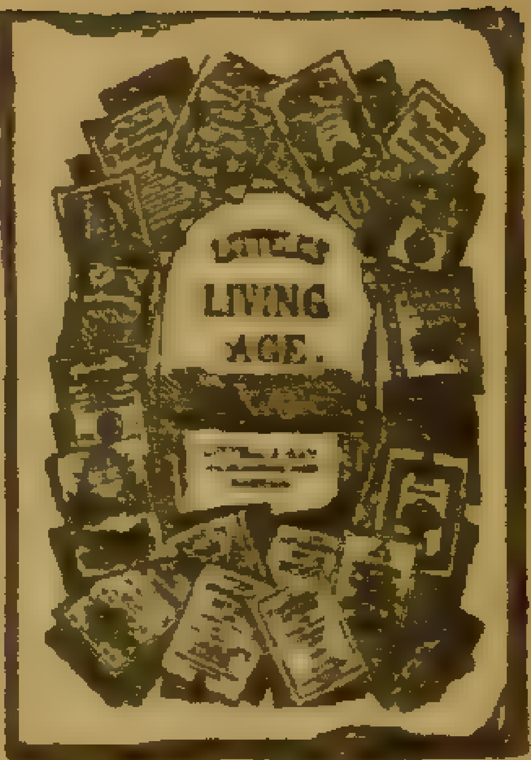

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A MONTHLY JOURNAL
DEVOTED TO THE NATURAL SCIENCES
IN THEIR WIDEST SENSE

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AMERICAN NATURALIST

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BIOMETRIC EVIDENCE IN THE PROBLEM OF THE PAIRED LIMBS OF THE VERTEBRATES.

BASHFORD DEAN.

From early development onward a fish is accurately poised in its living medium. Its long axis in a position of rest remains normally horizontal, in spite of the most varied changes in the size and shape of the fish's body and the shiftings and differentiation of its component parts. To preserve an accurate balance under conditions of rest as well as under the strain of the most active movement implies obviously a delicate adjustment of the morphological elements of the animal to the physical ones. And as the latter are relatively constant it follows that the acute strain in the evolution of the fish's body, both in ontogeny and phylogeny, has fallen upon the morphological elements. These, then, become subject to form changes, to position changes, and, most important, to physiological changes, to enable them to fulfill the mechanical requirements of habitat. To what degree the results are successful in adapting the vertebrate body to aquatic living can best be understood by comparison of the "area curves" and "entering

angles," not only among fishes of different groups but between fishes and cetaceans; for in these practically the same "lines" and "entering angles"[1] obtain.

From a physical standpoint we conclude, therefore, that the position of the gravity center of the animal during different stages of growth plays an important rôle in connection with its ever-increasing body length, and that special organs of balancing, *i.e.*, fins, will in their development be subject *par excellence* to the mechanical needs in shifting which the changing position of the gravity center and increasing body length demand.

From this standpoint, then, one can attack the long-troubled problem of the origin of the vertebrate limbs. Not, however, with the aim of solving it indisputably, — for this I firmly believe can be done only by the paleontologist, — but rather for the purpose of finding a probable clue to the labyrinthine confusion in latest morphological studies; for the voluminous conclusions of Braus, following Gegenbaurian teachings, and supported by Semon in his recent work on Ceratodus, — *cf.* also the related work of Klaatsch, — are vigorously denied by the newer phases of the fin-fold theory of Dohrn, Mollier, Rabl, and others, which in turn are in the latest time criticised by Fürbringer. In short, there is at present a deadlock in the discussion as to the mode of origin of the limbs of the vertebrates which cannot yet be loosened by orthodox embryological methods. Perhaps it will be bettered when a greater number of forms will have been examined, or when we shall have a clearer knowledge of the processes of accelerated and retarded development. Perhaps, on the other hand, to take a more somber view, it will never be adequately loosened by study of embryonic structures, since these may have been so modified during phylogeny as to mask hopelessly their true homologies. For the discussion has to a large measure narrowed itself down to the interpretation of embryological details, which if given fixed morphological weight become of great importance in theoretical discussion, but which are relatively valueless if

[1] The entering angle terminates with "wonderful uniformity" at 36 per cent of the total length of the animal, whether teleost or cetacean. *Cf.* especially H. DeB. Parsons, *Trans. Amer. Soc. Engineers*, vol. ix, 1888. 17 pp., 7 pls.

viewed as nothing more than adaptations to recent physiological needs. Thus, as an example, a tangle of nerves and blood vessels on the tailward side of a fin lobe of a shark may be either an important morphological condition as vestige of an ancestral, paddle-shaped, ceratodont fin, *e.g.*, as Braus maintains, or it may be nothing more than a newly developed condition to enable muscles and nerves to get in better touch with an enlarging and specializing margin of the fin, — which may indeed in its growth be developing from stage to stage special embryonic and larval movements. Again, the emancipation of nerves, vessels, and muscles from the basis of an embryonic fin may be the result either of the migration of a gill bar element in the Gegenbaurian sense, or merely of a purely local change in the requirements for balancing the constantly growing animal. For the center of gravity may shift as the body grows, and the fin (in sharks functional even when the "larva" is growing within the egg case) may thus have to move forward and backward as mechanical needs demand.

"But," the Gegenbaurian would maintain, "*our* theory is supported by fin migration. Of course we are willing to grant that the record is obscured by cenogensis, but we have still morphological evidence that the ventral fin migrates backward, and that the pectoral is relatively stationary, its girdle resembling the adjacent branchial arches. And we believe, moreover, that the mechanical fin needs, which have been noted above, are of the utmost importance, since it is in response to them that the ventral fin has traveled backward and that the pectoral fin has retained, relatively, its primitive position. Indeed, the very perfect segmental character of the ventral fin can be best explained in terms of a continued hindward migration, for the ventral is not the more steadfast and more primitive fin."

Now, it has long seemed to me that such a line of argument could be invalidated if it could be shown that during the growth of the individual the fins responded to their mechanical requirements in just the opposite way; that is, that the ventral fin was *not*, and that the pectoral fin *was*, the migrating element. And the present paper has grown out of an attempt to trace,

and to this end by biometric methods, the actual stages in the development of the paired fins in accordance with their physical requirements. Assuming, for example, a complete series of a form in which the limb characters can be favorably examined, say a shark,[1] in stages ranging from adult to embryos in which the paired limbs are just appearing as distinct structures, we can then determine by measurement what change occurs from stage to stage in the position of the gravity center (with reference to the total length of the animal), and by similar measurement of the fins in similar terms we can ascertain what ratio these measurements bear to the possible shifting of this center. For all will admit that the fins themselves, as light and delicate structures, can in their growth play little direct part as a *cause* of the changing position of the center of gravity, and that their migration, forward or backward, is rather an outcome of the shifting of bulkier organs, — muscles, brain, viscera, sense organs. We can therefore conclude that by such a system of measurements one can obtain evidence as to whether the ventral fins migrate backward, *i.e.*, in terms of the total length of the individual, and show the correlation in growth with the pectorals which the Gegenbaurian theory demands; or whether, on the other hand, it is the ventrals which are constant, and resemble the dorsal fins, while pectorals play the part of the mobile and specializing members.

The following notes are based upon a cestraciont shark,[2] a form particularly interesting from the standpoint of morphological conservatism, since there is reason to believe that it has been little modified since Carboniferous times. And the measurements are recorded of sixty individuals ranging in length from 330 mm. to 14.5 mm. For this careful and laborious computation I am much indebted to my former student, Prof. C. H. Brookover, who made it the beginning of a research

[1] Better, of course, would be sets of many genera and species; but as long as these are lacking, we may base conclusions as to essential characters upon the ontogeny of a single form.

[2] *Heterodontus japonicus* Macleay. The embryos were collected during the writer's visit to Japan, 1901, thanks to the many privileges which he enjoyed at Misaki as guest of the Imperial University of Tokyo.

upon the general problem of limb migration. He was, however, unable to carry out his plans, and he generously turned over to me his measurements for use in the present paper.

Details of Data.

Straight specimens were selected for measurement. Gravity center was determined in terms of the total length [1] by balancing the specimen either on a knife-edge or within the delicate tips of curved forceps. By this simple method the limit of error was found to be surprisingly small, estimated by repeated tests at about 1 per cent. In the measurements individual variations are taken into account, since it was found that a more advanced embryo is sometimes smaller in size and variable slightly in proportions, and in preparing the table of averages as plotted in Fig. 1 this source of error has been largely counterbalanced by the use of guide points representing the average of several (usually four) successive individuals. All measurements are computed in percentage of the total length of the specimen, and are estimated from the snout tip. The landmarks whose relative position is computed are indicated graphically in the present Fig. 1, *i.e.*, anterior margins of pectoral, of ventral, and of dorsal fins, and posterior margins of pectorals and ventrals. Of the latter margin the functional (dermal) one is alone considered.

The Result of this Analysis.

The *center of gravity* is found to shift forward (about 5 per cent of the total length) in the earlier embryos (embryos from 27 mm. to about 6 mm.), in later stages (up to embryos of 200 mm.) backward to the extent of about 8 per cent of the total length. In well-grown specimens the position of the gravity center remains practically unchanged.

The *pectoral fin* undergoes conspicuous changes: from the time it can be distinctly differentiated from the ventrals it

[1] The transverse plane in which the center occurs was alone determined; its more accurate position *within this plane* has evidently no bearing upon the present problem.

TABULATED MEASUREMENTS OF FINS AND GRAVITY CENTER OF CESTRACION EMBRYOS.

(BY C. H. BROOKOVER.)

	Total Length.	From Snout Tip to						
		Center Gravity.	Ant. Marg. Pect. Fin.	Post. Marg. Pect. Fin.	Ant. Marg. Vent. Fin.	Post. Marg. Vent. Fin.	First Dorsal.	Second Dorsal.
	mm.	%	%	%	%	%	%	%
1	14.5	—	31 +	38 —	—	—	—	—
2	15	—	32	40	—	—	—	—
3	15	—	27	35 —	—	—	—	—
4	20.5	—	26	38 +	42 +	49 +	no spine 39	no spine 63 —
5	21.5	—	25 —	32 +	41 —	48 +	no spine 37 +	no spine 56 —
6	24 —	—	24 +	31 —	37 +	44 —	no spine 35 +	58 +
7	24	—	28 —	37 —	45 —	52 +	40 —	62 +
8	26.5	—	26 +	32 +	40 +	48 —	33 —	53 —
9	26.5	31	27 —	33 —	41 +	48 +	34	57
10	27	28	24 +	30	37	44 +	34 —	53
11	27	26 —	25 —	31 —	39 —	45 +	33	53
12	27.5	—	24 +	31 +	38 +	46 —	32	57
13	28	—	21	28	32	39	30 bent	50 bent
14	31	—	23	31	39	45	32	55
15	31	—	25	31	37	43	32	50
16	32.5	—	24	30	38	41	29	50
17	34	—	22	28	34	40	31	50
18	34.5	—	22	29	34	40	28	49
19	35	—	24	31	38	45	30	51
20	35	—	20	26	30	38	29	48
21	35	—	22	28	34	40	29	50
22	37.5	—	23	29	31	45	29	50
23	38	—	22	28	39	46	30	50
24	39	—	22	29	39	44	29	51
25	39	—	21	27	35	43	27	50
26	39	—	21	27	34	40	27	48
27	40	—	20	26	32	40	28	48
28	40	—	21	29	36	42	28	50
29	40	26	21	27	35	41	27	48
30	40.5	—	20	26	35	40	28	48
31	41	—	22	27	35	43	26	47
32	41	—	21	29	34	41	29	50
33	41.5	—	20	26	30	39	26	47
34	42.5	—	22	28	36	42	28	50
35	43	—	22	29	39	44	29	49
36	43	26	21	26	34	40	25	45
37	44.5	26	20	26	34	39	29	50
38	44.5	—	21	27	37	43	27	49
39	45	—	22	27	36	43	27	48
40	46	—	20	26	34	38	27	48
41	46.5	31	22	27	35	42	27	48
42	50	25	20	26	37	41	27	46
43	50	24	21	25	32	38	24	43
44	50	25	20	26	33	40	25	47
45	51	—	20	26	33	40	25	50
46	55	25	19	25	35	41	26	46
47	59.5	24	18	24	31	39	23	50
48	60	23	21	27	34	40	25	47
49	61	25	18	25	34	41	25	48
50	62	23	19	26	34	41	27	47
51	66	26	19	23	33	40	24	46
52	72	25	17	26	33	41	24	51
53	73	26	18	30	37	42	27	50
54	81	25	19	29	36	43	26	52
55	82	24	19	30	37	43	27	52
56	105	27	19	30	37	46	27	53
57	187	31	17	42	37	50	27	57
58	197	32	18	42	41	53	30	57
59	280	30	18	39	41	53	31	59
60	330	30	18	43	41	53	29	59

increases greatly in size, measured antero-posteriorly, from 6 per cent of length to about 24 per cent, its anterior and posterior margins undergoing somewhat different fates. The anterior rim of the fin passes forward, suddenly in earlier stages, slowly in later ones, altogether a distance of over 12 per cent of the total length, a distance considerable enough, I take it, to entail important adaptive changes in the structures of the encroached-upon region, especially in view of the fact that this fin margin grows forward as the gravity center passes backward. (*Cf.* also *infra*, *re* the continuous hindward growth of the outer gill slits.) Interesting in this connection is the slight variant in embryos of about 80 mm.; here, the gravity center shifting a little forward, the anterior fin margin passes backward, thus indicating a nice adjustment in the mechanical relations between them. In a general way the advance of the anterior rim of the pectoral is at the same pace as the retreat of the center of gravity. The behavior of the hinder rim of the pectoral shows a less close adjustment to the gravity center. In early stages this fin rim passes forward (about 11 per cent between stages of 15 mm. to 56 mm.) to about the transverse plane of the center of gravity; thereafter, however, it grows hindward, gradually increasing the distance from the gravity center (11 per cent) (and from the anterior fin rim (total, 24 per cent)). By this noteworthy hindward growth it comes in the older stages to overlap somewhat the anterior rim of the ventral fin.

The *ventral fin* is conservative in its position during growth: measuring about 6 per cent of the total length in earlier stages, it increases to but 12 per cent in latest ones, a gain in percentage of but 6 per cent as against 18 per cent in the pectoral. Like the pectoral, the entire fin passes slightly forward in younger stages, then slightly backward. The anterior rim remains almost fixed with reference to the body length, the posterior passing slightly backward to a degree corresponding almost exactly with the shifting of the gravity center. Thus, in an embryo of about 80 mm. the center of gravity is 18 per cent in advance of this rim, in one of 115 mm. 19 per cent, in one of 145 mm. 19 per cent, of 187 mm. 19 per cent, a

correspondence so close that we can interpret it only in terms of cause and effect.

The *dorsal fins* are even more conservative in position than the ventrals. In the first place they maintain practically the same relative distance from one another, measured from the anterior rim of the fins[1]: thus, in a specimen of 21 mm. the interval measures about 23 per cent, of 40 mm. about 22 per cent, of 60 mm. 23 per cent, of 82 mm. 25 per cent, of 105 mm. 26 per cent, of 197 mm. 27 per cent; in other words, between the two fins there is but a slight variation in the interval (say, 5 per cent of the entire length) in stages widely different in size (*e.g.*, measuring between 20 and 200 mm.). In general, however, we note that the growth of the anterior rims of first dorsal and ventral are indicated by parallel lines, and similarly the growth of the anterior rim of the second dorsal and the posterior rim of the ventral.

Summary.

The foregoing characters yield what seems to me convincing evidence that the pectoral fin is subject to changes with respect to the gravity center, *i.e.*, physical changes, which cause it to become more highly specialized than the ventral fin, and that the latter is conservative, after the fashion of the unpaired fins. The result of biometric data, it will be seen, confirms strikingly the views of the fin-fold theorists, most clearly expressed in this particular regard by Wiedersheim in his "Gliedmassenskelet." On the other hand, the present study yields *no evidence that there has ever been a migration of the fins in the Gegenbaurian sense*; thus, we find no reason to believe that the ventral fin is a structure which has shifted its position from in front hindward; it is indeed in about the same position fore and aft in the adult as in early embryos (20 mm.). It is important, furthermore, that the only fin (leaving anal and caudal out of discussion) whose anterior margin passes forward is the pectoral, since with this condition is correlated the fact that this

[1] In the younger stages the measurement was made from the actual most anterior point of the fin; in the later, when a spine appears, from the point where the anterior fin rim, if produced, would intersect the dorsal-most line of the body.

rim alone is in advance of the gravity center. Thus, as this center passes backward, the posterior margin of the ventral fin is found to follow it *pari passu*, and, as effecting a counter balance, like equal weights placed in opposite scale pans, the anterior rim of the pectoral passes headward.

Again, contrasting the embryos shown drawn to scale in Fig. 1, and referring now to the position of the external gill openings, we note that there is a marked tendency for these openings to pass backward. In the earlier specimens all are widely interspaced and the last is well in front of the fore rim of the pectoral; in the next embryo the openings are drawn together, altogether somewhat tailward; and in the latest, as far at least as to the second opening, the series have taken a position hindward of the rim of the pectoral.

More concretely (measurements taken from the specimens):

Gill Opening.	Percentage of Length from Snout Tip.			Percentage of Tailward Migration.
	Stage 1.	*Stage 2.*	*Stage 3.*	
I	11 %	13 %	16 %	5 %
V	19 %	19 %	23.5 %	4.5 %

In other words, as far as these openings are concerned, and with them the *outer part* at least of the gill canal, it is evident that in the older stages a definite migration has taken place, to a degree that, in terms of the total length of the animal, the gill openings come to occupy a position in the body wall which is largely behind that of the earlier stages. Numerically considered, the interval between gill openings I and V is about 8 per cent of total length in stages 1 and 3; but in the latter the region of the gill openings is nearly 5 per cent farther tailward; therefore, in this stage the openings occupy a position in the body surface which is about five-eighths new, *i.e.*, never before occupied by gills. From this it follows that *the gill region, at least in its outer part, shows no affinity during proportional growth with the neighboring region of the pectoral fin. In fact, from an early stage onward, they are evidently growing in opposite directions.*

If, now, we figure the matter up, we find that the distance the gill openings pass tailward (contrasting embryos varying from about 20 to 300 mm.), added to the distance which the anterior rim of the pectoral passes headward, makes the considerable sum of 20 per cent of the length of the animal. And from this it follows that there occurs in this region a process of "shortening up," which is surely enough to account for the presence of anastomosing vessels, blended muscle bands, plexus of nerves, and "collectors." The presence of such complicated structures,[1] especially in the region of the anterior or posterior rim of a (pectoral) fin, is therefore to no little degree a product of the mechanical needs of fin migration.

COLUMBIA UNIVERSITY, October 17, 1902.

[1] Another complicating feature to be considered in this connection is the disposition of segments arising in the caudal region and growing cephalad. In the earlier embryos (15 to 20 mm.) the total number of segments behind the last gill arch is enclosed within a space measuring about 80 per cent of the entire length; later specimens (300 mm.) include the segments within a space of 76 per cent. The size of the embryo at which the formation of new segments ceases has not been determined in the present form, nor is it as yet ascertained in kindred forms.

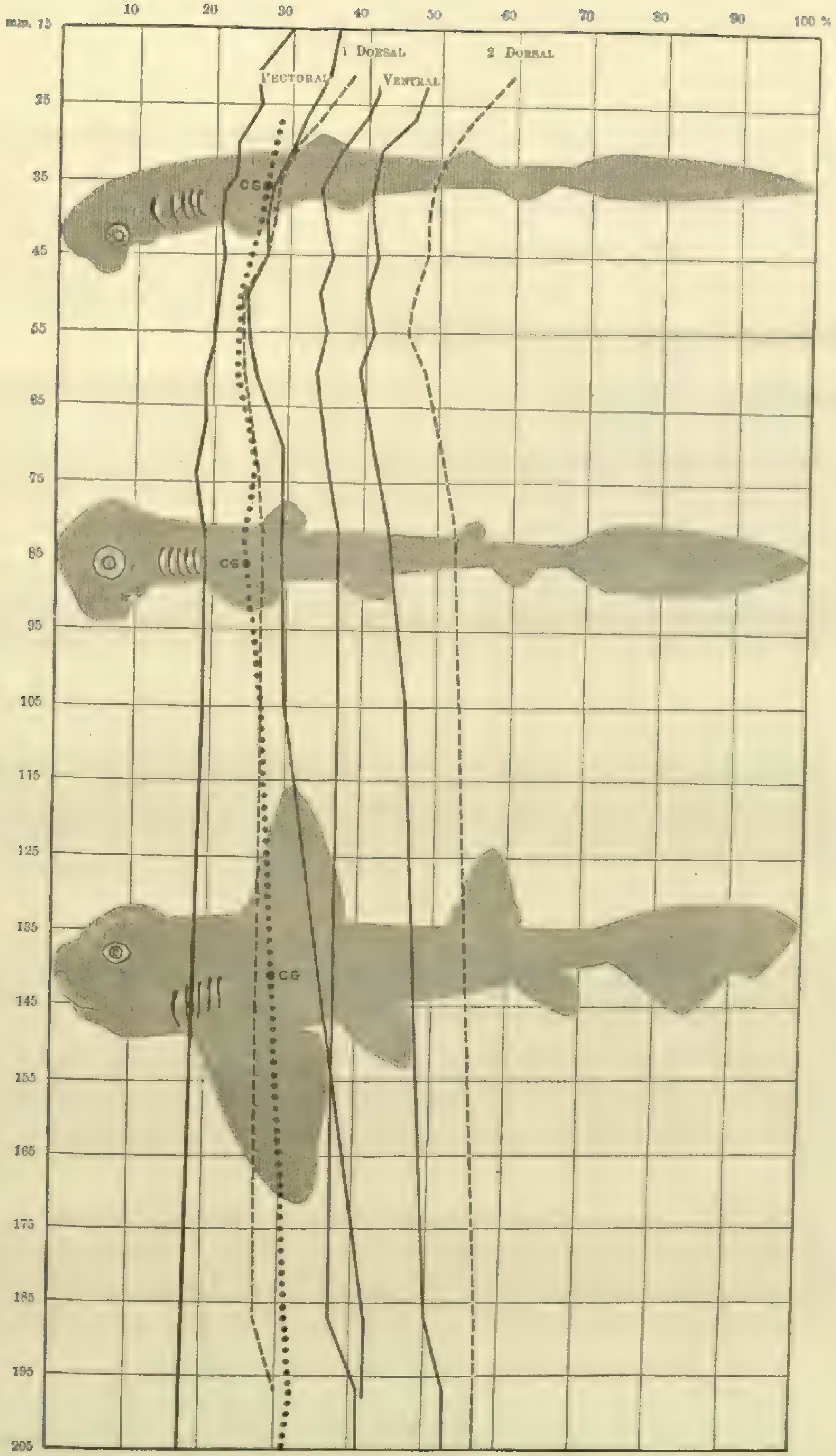

Fig. 1. — Cestracion at different growth stages. Tabulated measurements of sixty specimens indicating the position of the center of gravity and of the paired dorsal fins. In all specimens in the series the measurements are reduced to a common scale, *i.e.*, to a uniform length, which is here subdivided in percentage. The lengths of the specimens measured are indicated (in millimeters) in the vertical columns at the left. The landmarks in the different stages measured are connected by lines as follows: gravity centers, *C G*, by dots; fin margins of pectoral by heavy lines; of ventral by light lines; of dorsals by dashes. Outlines of stages of 35, 85, and 138 mm. are introduced to show these lines in their relative positions.

NOTICE OF INTERESTING NEW FORMS OF CARBONIFEROUS FISH REMAINS.

C. R. EASTMAN.

THROUGH the kindness of Professor G. Hambach, of Washington University, St. Louis, a number of highly instructive Carboniferous fish remains have recently been brought to the writer's attention, two of which seem to possess considerable interest, and are therefore made the subject of the following notice. The first to which attention is invited is a remarkable specimen of Erismacanthus from the vicinity of St. Louis, now preserved in the private collection of Dr. Hambach. It is unquestionably the largest and at the same time most perfect spine belonging to this genus yet brought to light, and appears to be distinct from other described species. The second specimen noticed in the present paper yields new information regarding the dentition of *Campodus corrugatus*, and is from the Coal Measures of Winchester, Illinois.

Genus Erismacanthus M'Coy.

The two European and one American species of this genus that have been described are evidently closely related to Physonemus, but differ in that the spines are divaricated, the two branches extending in opposite directions in the same vertical plane. The imperfect ichthyodorulites known as Gampsacanthus, Lecracanthus, and Dipriacanthus are also of the same general nature, and all these bodies are interpreted by most authors as lateral head spines of presumably cochliodont or petalodont sharks. The occurrence of spines on either side of the head in sharks and chimæroids has been observed in a number of forms, such as in *Oracanthus armigerus* Traquair, from the Calciferous sandstone of Eskdale, Scotland, in the Permian *Menaspis armata*, and in Mesozoic cestracionts (Hybodus).

The Physonemus group of spines has been theoretically associated by Jaekel with the teeth of petalodonts, but this conjecture has not been corroborated as yet by any direct evidence.

Very interesting stages of modification are displayed by the group of Physonemus-like spines throughout their existence in the Lower Carboniferous. The earliest and most primitive forms of the typical genus are found in the Kinderhook, in accompaniment with small forms of Stethacanthus. The two or more species of Kinderhook Physonemi that are known are of small size, attenuated, and quite destitute of surface ornamentation. Erismacanthus is also represented in the Kinderhook by two small, comparatively unornamented species, and it is noteworthy that the branched condition is here rudimentary. The Burlington species of Physonemus and Stethacanthus display a marked increase in size, but the ornamentation is feeble, and remains so throughout the stage represented by the Keokuk Limestone. Stethacanthus seems to have attained its maximum size in the Keokuk, as Physonemus did in the Burlington (*P. gigas* N. and W.), a considerable falling off in this respect being true of both genera in the St. Louis division. The spines of Stethacanthus remain unornamented from their first appearance in the Berea Grit of Ohio until their extinction in the St. Louis Limestone, but those of Physonemus and Erismacanthus increase in complexity of ornamentation throughout the Mississippian series, ultimately displaying great elaboration. An inspection of the forms illustrated in Plate XXII of the sixth volume of the *Illinois Palæontology*, or of the large spine immediately to be described, will, we think, satisfy any one as to the correctness of this latter statement and of the above generalizations.

Erismacanthus formosus sp. nov. (Fig. 1).

Definition. — A very large species, the spines attaining a total length of at least 22 cm. Anterior branch stout, much produced, gently arched, one side more or less flattened and provided with a double row of obtusely conical denticles, the other smooth and convex, appearing as if imbedded. Posterior spine considerably arched, prominently keeled, laterally compressed, and bearing a double series of closely set denticles along the distal half of the posterior margin. The posterior spine is relatively wide in its

basal portion, and tapers gradually toward the acuminate distal end ; its surface is ornamented with numerous longitudinal costæ which increase by bifurcation, and by rows of small, rounded or spiniform tubercles occupying the intercostal spaces, these being especially numerous on the broad basal portion of the spine, and extending also over the proximal portion of the anterior branch.

The above description is based upon the remarkable spine shown in Fig. 1, together with two or three imperfect specimens, all collected by Dr. Hambach from the St. Louis Limestone in the vicinity of St. Louis, Missouri. The large specimen has a total length of 21.5 cm., of which the anterior branch forms about four-sevenths and the posterior spine three-sevenths. It is nearly seven times the size of *E. maccoyanus*

FIG. 1.—*Erismacanthus formosus* sp. nov. St. Louis Limestone; St. Louis, Mo. Lateral aspect of spine referred to the left side of the head, × ½. Cross sections are given of both branches at the points indicated by dotted lines, and three of the posterior denticles are shown slightly larger than the natural size.

St. J. and W., which accompanies it in the same formation, and twice that of *E. jonesi* M'Coy, the largest known European species. From both of these the present species differs not only in size, but also in the form of cross section and denticulations of the anterior branch, as well as in the general surface ornamentation. It appears improbable that the anterior branch was terminated by a cluster of denticles, but there is a double row of about twenty robust conical enameled bosses along the flattened face of this arm, which have evidently become obtuse through wear. This flattened face was probably entirely exposed, but there is reason to believe that the opposite, or more convex face, was buried in the integument. Its smooth surface presents the same appearance as the inserted portion of most fin spines, and betrays none of the usual indications of wear.

Obviously if this portion of the spine had projected freely, and were not anchored by insertion in the soft parts, it would have been not only a useless appendage but a positive hindrance to the creature, besides being constantly exposed to injury; but if we conceive of it as inserted in the integument in the same manner as the anterior prolongation of *Oracanthus vetustus*,[1] its function as a defensive organ and as a support for the posterior spine is readily understood. Evidence that this was a paired spine, and therefore not occupying a position in the median line of the back or of the head, is afforded by the fact that the exposed face of the anterior branch is turned so as to present the denticles toward the left-hand side; and the organ may therefore be interpreted as a lateral head spine belonging to the left side of the body.

The posterior spine is very similar to the single defenses of Physonemus, but is more strongly keeled and broader at the base. The distal half of the posterior margin bears a double row of closely set denticles resembling those of *E. maccoyanus*. The sides of the spine are occupied by numerous fine, smooth longitudinal costæ, of which about fifteen are to be counted along the line where the cross section shown in the figure is taken. The intercostal spaces, more particularly in the basal portion of the spine, are studded with numerous small tubercles, which are stellate in the unworn condition, and vary in shape between conical and spiniform. In many cases their summits are mucronate with the points reflected toward the basal portion of the spine, and the resemblance of these tubercles to certain types of placoid scales is very marked. It is probable that the imperfect spine illustrated in Pl. XXII, Fig. 3, of the sixth volume of the *Illinois Palæontology*, represents a young individual of this species.

Genus Campodus de Koninck.

This genus of cestraciont sharks is represented in the Coal Measures of North America by three species, one of which — *C. variabilis* (N. and W.) — is of importance as affording a

[1] *Cf.* J. S. Newberry, *Trans. N. Y. Acad. Sci.*, vol. xvi (1897), p. 287, Pl. XXII, Fig. 3.

complete insight into the dentition of Orodus-like forms. The species described by Newberry and Worthen as *C. corrugatus* has been known hitherto only by a few of the lateral teeth,

FIG. 2. — *Campodus corrugatus* (N. and W.). Coal Measures; Winchester, Ill. Oral aspect of a portion of the symphysial dentition, × ¾.

and we have been without information regarding the symphysial series. One specimen, however, of the symphysial dentition has recently come to light, and seems worthy of particular description.

Campodus corrugatus (Newberry and Worthen) (Fig. 2).

The symphysial dentition of this species differs from that of *C. variabilis* in that the individual teeth are much more robust, less intimately fused with one another, and less differentiated in form from the lateral series; they are also apparently fewer in number than in the corresponding series of *C. variabilis.* All these characters point to the conclusion that as between the two species the latter is much more highly specialized and stands nearer to the line which gave off Edestus and other extremely modified cestracionts.[1]

The unique specimen of *C. corrugatus* shown in Fig. 2 exhibits five very robust teeth, which are recognizable by their peculiar form as having pertained to the symphysial series. Of how many teeth the entire series was constituted cannot be told, but owing to the large size of the teeth it is probable that the number was less than in *C. variabilis*, which has as many as thirteen. The apical extremities of the crowns have unfortunately all been broken away, and the bilateral symmetry of the series has been disturbed by mechanical agencies since the death of the creature, so that the teeth appear to succeed one another in spiral fashion, instead of being arched in a single plane. The apical portions of the crowns differ from those of *C. variabilis*, also, in that they are more elevated, and are inclined backward at a slight angle.

The coronal surface of each tooth is marked by a prominent transverse crest, from which numerous branches are given off approximately at right angles on either side. The anterior margins of the crowns are very prominently buttressed, an especially large projection occurring in the median line on both the anterior and posterior faces. Fig. 2 is photographed from a cast of the original specimen, which was obtained from Bates and Company's coal mine at Winchester, Illinois.

[1] A detailed account of the dentition of Edestus and related forms is given in *Bull. Mus. Comp. Zoöl.*, vol. xl, No. 3, 1902.

THE MICROCOSM OF THE DRIFT LINE.

LÆTITIA M. SNOW.

In the spring of 1902 my attention was called to the extremely interesting life relations of insects along and around the line of drift thrown up by the waters of Lake Michigan, and a series of collections and observations were made between April 14 and May 31. The collections included one hundred and fourteen species, only fifty-one of which it was possible, with the means at hand, to identify. The specimens have, however, been preserved.

Physical Features.

As with life everywhere, the physical features of the habitat are of great importance to the population. For instance, on Windsor Park beach, including the region north to Seventy-Second Street and south to the Steel Works, the forms were, as a rule, much more abundant than on the two beaches in Jackson Park. On the former beach the gradient is low and the sand smooth ; the water action is rather gentle, the insects stay when the water retreats, and the fine sand keeps them on the surface. At Jackson Park beaches, on the other hand, unless the water has recently been high and beyond the pebble zone, the collecting is poor. In the pebble zone the gradient is greater, the water action greater, and there is the possibility of the insects being washed out again into the lake. That the physical conditions of the beach account for the greater number of forms, and not the fact that collections at the two places were made at different times, may be proved by the fact that on the same day a pebble region of beach north of Windsor Park gave no results, while a smooth region yielded a number of forms.

CAUSES OF DISTRIBUTION.

The waves of the lake wash up great quantities of refuse, among which are numbers of insects. These animals may be either land or water forms; if the former, they have either come directly upon the shore, or have flown lakeward or been blown by an off-shore wind, and then been washed in, dead or dying. On account of the lake current moving southward along this region, specimens collected at Chicago may have come from points farther north (13). To this group of stranded land forms belong the ladybirds (Coccinellidæ), Chrysomelidæ, leaf-eating Scarabæidæ and Carabidæ, possibly the Elateridæ, Lucanidæ, and the Rhyncophora among the Coleoptera, the Lygæidæ and Pentatomidæ among the Hemiptera, the Hymenoptera, Neuroptera, Trichoptera, and Lepidoptera, — all of which are herbivorous. Also to this group belong some predaceous carabids and one roach. To the stranded water forms belong *Benacus griseus*, *Hydrophilus triangularis*, and two other water beetles.

These stranded forms may revive and depart, may serve as food for predaceous forms, or, if dead, fall to the share of the scavenger insects. The flies and ants are undoubtedly scavenger forms, and inhabit this region on account of the food supply. In this class I would also place a small carabid beetle (undetermined) which occurred for a while in great numbers under stones and débris, so as to preclude the idea of its having been stranded during migration. Several small beetles seem to have this scavenger habit; for example, three Staphylinidæ, some Scarabæidæ, and several Carabidæ. In this latter family we find some predaceous forms which seem to inhabit this region normally, to feed on the dying insects or on their destroyers; for example, several black forms (undetermined) and *Galerita janus*. The spiders are also predaceous, and feed on the flies, ants, and other small living insects. I might add that birds come in as a final factor and eat these various forms.

ORDER OF SUCCESSION.

These insects do not come all at once, nor "hit or miss," but follow a fairly regular order of succession. It was seldom that the same form was dominant at two visits. Between April 14 and 21 very few insects were found, and no regular record was kept. The temperature was cool and the winds variable during that period. On April 25, after four days of S., S.W., and W. winds, followed by E. and S.E. winds, more forms appeared. Two days of strong (thirty to forty miles per hour) W. wind, followed by a S.E. wind, brought in a few forms on

DATE.	WIND PREVIOUS TO COLL.			WIND, DAY OF COLL.		TEMP. F.		SPECIES.		
	Days.	Direction.	Av. Vel.	Direction.	Av. Vel.	Max.	Min.	New.	Old.	Total.
Apr. 25	2	W. to E.	19	S.E.	14	69	42	10	1	11
28	2	W.	37½	S.E.	15	61	48	3	0	3
May 2	2	E. to N.E.	20	S.W.	18	82	53	37	5	42
12	3	N.E. to E. to N.E.	21⅔	N.E.	10	56	43	27	10	37
16	7	N.E. to E.	$16\frac{6}{7}$	E.	10	61	48	6	19	25
23	2	S.W. to S.	12½	S.E.	10	77	61	13	19	32
27	2	W. to N.W.	15	N.E.	18	50	40	8	7	15
31	2	S.W.	17½	S.E.	15	75	60	2	14	16

(Data kindly furnished by the U.S. Weather Bureau, Chicago, Ill.)

April 28. All this time the temperature was cool, only once rising over 69° F. On May 2 a N.E. wind (twenty miles), preceded by a W. wind, brought in a good many forms, thirty-seven new species being found, besides several previously collected; the rising temperature (53°–82°) probably influenced the numbers. On May 12 twenty-five new species were found, besides an abundance of old ones. This rich supply was probably due to three days of W. and S.W. wind, followed by four days of N.E. and E. wind (averaging eighteen and three-fourths miles), which continued until May 16 with decreased velocity (thirteen and one-fourth miles), the temperature never exceeding 61° F. On this day only five new

species appeared, but numbers of old ones were found. On May 23, after a warm period with S., S.W., and S.E. winds of low velocity, fourteen new species were collected, a few old ones appearing. A N.E. wind on May 27, preceded by W. and N.W. winds of moderate velocity, brought in countless Colorado potato beetles and ten new species, the temperature dropping twenty degrees in two days. On May 31 a S.W., followed by a S.E., wind brought only two new species, but a good many old ones occurred. These results are placed on the preceding page in tabular form.

DOMINANT FORMS.

The first form to predominate notably was *Chrysomela elegans* (May 2), while *Hippodamia parenthesis* came in a good second. The little *Coccinella sanguinea* occurred throughout the season in about the same numbers, but absence of other forms made it at times the dominant species. Black carabids occur also throughout, but never as dominant forms. The next visit, May 12, showed *Diabrotica vittata* as the characteristic species, while of Chrysomela only a few specimens were found. The small brown and black scavenger carabid was present in great numbers, and should probably be classed as the dominant form. *Coccinella sanguinea* was numerous, as were also black carabids. The following collection showed the Diabrotica, although not the characteristic species, still occurring in fair numbers; the scavenger carabid seemed to be the most numerous form, with quantities of *Coccinella sanguinea.* Of the larger forms Bombus sp.? and *Hydrophilus triangularis* were the most important. This time (May 16) marked the first occurrence of *Galerita janus*, and the flies were first noted. The various forms of Hemiptera occurred throughout the collecting trips, but were never dominant forms. On May 23 the Colorado potato beetle (*Leptinotarsa decemlineata*) was the dominant form at Jackson Park. This appears to have been the vanguard of the great "migration" which took place on, or just before, May 27; for on that date the beach at Cheltenham was nearly covered with the beetles,

dead, dying, or active. In the latter case they had in many instances crawled up on stones and driftwood, until the surfaces of such articles were, in places, covered with them, sometimes two layers deep. On May 31, however, very few live ones remained, and the total number of individuals was greatly diminished. The form that approached the potato beetle in number on May 27 was the May beetle, or June bug (Lachnosterna sp. ?).

Besides those above mentioned, other forms occurred in greater or less abundance at different times, some running through the whole period, some starting late and continuing to the end, some starting early and disappearing.

Migrations.

Would the fact that certain forms culminated at certain times indicate that they simply reached the adult stage at that time, laid their eggs and disappeared, or that they were performing mass movements, broadly called "migrations"? The great swarm of potato beetles on May 27 closely resembled mass movements recorded by many authors, in that the number was large and that the animals were found on the 27th and by the 31st had almost entirely disappeared, no new ones appearing. If it were merely a general emergence, it is not likely they would have been found only along the lake front. This great washing up of one species recalls the predominance of crickets (*Nemobius fasciatus*) described by Needham (1).

Much has been written on this subject, both descriptive and theoretical, but the problems as to the "why" and "whither" of insect flights have never been solved. The search for food has been suggested as the cause, and the suggestion has been accepted by many as at least a secondary factor. In some cases over-production, followed by a scarcity of food, would seem a sufficient reason for the movement; as, for instance, the migrations of locusts, both in this and other countries (2, 3). Certain examples of the flights of dragon flies point to the same cause (3, p. 509; 4; 10). Kobelt (3) quotes Gätke as saying: "Es ist schon darauf hingewiesen worden,

dass auch die Bewegung der Nachtschmetterlinge meteorologischen Beeinflussungen unterworfen sind. Diese Ansicht stützt sich auf wiederholte Beobachtungen, nach welchen dieselben unter gleichen Bedingungen wie die Vögel, und fast immer zusammen mit diesen in ostwestlicher Richtung hier vorbeiziehen"; which may be the key to the whole question. As far as I am aware, no barometric observations have been made directly on the subject of insect migration (15).

That a feeling of hunger is not alone a sufficient cause for some of the direct flights recorded, is shown by the fact that butterflies often continue in their path, over the very flowers they use for food, only a chance one stopping on the way (3, p. 509). Also, if they simply spread out to find food, the progression would be diffuse, directions inclined to be random, and the advance a gradual one, as is the case with the spring "dispersal through isolated individuals" of Danais (5), which go north as the spring advances, various generations taking part in the advance.

In many instances the direction of flight has not been noted, but in Europe the general tendency seems to be from east to west. In our country, however, no such law appears to hold. More attention has been paid to the consideration of whether the animals, chiefly butterflies, flew against or with the wind, some holding that the latter feat was impossible. That it is at least possible, has been shown by some direct observations (6, 7).

It has been suggested that, as in some cases the swarm was composed of individuals of one sex (males), the flight originated in a search for mates; but as the absence of females can be explained in some instances by their wingless condition (8, 1900, p. 13), while in most observations the sexes were nearly equal in number, this cause may apparently be ruled out.

If they are then not necessarily merely drifted by the wind, or impelled by immediate hunger or by the sexual instinct, why do they follow such direct routes, fly with such apparent aim, and often repeat the flight at intervals? Walker attributes it to "a propensity to migrate" (8, 1901, p. 353), thus throwing it back upon hereditary tendencies, while Keferstein (4) adds to over-production and some aid from wind,

an unknown impulse to take a common migration. Riley (5) makes the statement that "all insects acquire the migratory instinct when crowded together through excessive multiplication." The probable response to meteorological influences has been noted.

Hancock (9) distinguishes between dispersal and migration in the statement, "Individuals of a species which effect a more or less regular periodical change in their habitat are truly migratory. Migrations may be primary, consisting of local flights, such as movements by insects hatched in temporary regions, to which they confine themselves to passing to and fro, from point to point; or secondary, as the repeated periodical changes of residence covering foreign fields, which naturally establishes a nomadic habit." In addition to these distinctions it is suggested that the term "migrations" be confined to periodical changes of habitat resulting from the normal sequence of temperature and season, while such abnormal occurrences as the devastating swarms of Rocky Mountain locusts or irregular and unusual swarms, as in certain instances of butterfly, moth, and dragon-fly flights, be given, temporarily at least, the term "immigration." Mr. Hancock's "primary migrations or local flights" would be simply dispersal flights of individuals or groups of individuals within their area of distribution.

Was the flight of Colorado potato beetles on May 27 a dispersal (or local) flight, diverted out of its course and driven lakeward by west winds, or was it a periodic migration? The predominance of other insects at various times was probably due to the spreading of groups of individuals by local flights: may not these local flights give some evidence of the dispersal paths of various species?

Conclusion.

By whatever means the animals reached the region, — by migration or dispersal movement, — the life relations of the beach are not altered. We have here a little community of food providers and food obtainers, whose population varies with the season, the wind (probably), the beach conditions,

and the relative abundance of the various forms. For example, we found (1) the occurrence was in succession; (2) the population increased apparently at times when an offshore wind was followed by a lake breeze; (3) it also increased with the temperature; (4) the greatest numbers occurred on beaches of low gradient and smooth, fine sand; (5) the abundance of scavenger forms depended upon the abundance of dead herbivorous and predaceous forms and other refuse; (6) the abundance of predaceous forms depended upon the presence of the active scavenger and herbivorous and smaller predaceous forms.

I gratefully acknowledge the kindness of Dr. Charles B. Davenport and Mr. Charles C. Adams, and present my thanks for their assistance in identification and for valuable advice and suggestions.

Hull Zoölogical Laboratory,
July 18, 1902.

List.

Of the one hundred and fourteen species collected fifty-one were identified, the whole collection being placed in the following orders and (where possible) families: —

Coleoptera, 75: Carabidæ, 33; Scarabæidæ, 10; Chrysomelidæ, 9; Coccinellidæ, 7; Staphylinidæ, 3; Hydrophilidæ, 3; Cerambycidæ, 2; Elateridæ, 2; Silphidæ, 1; Histeridæ, 1; Halipidæ, 1; Lucanidæ, 1; Curculionidæ, 1; Calandridæ, 1.

Hemiptera, 11: Pentatomidæ, 5; Lygæidæ, 2; Reduviidæ, 1; unknown, 1.

Diptera, 10: Muscidæ, 5; Syrphidæ, 2; Phoridæ, 1; Tachinidæ, 1 (?); unknown, 1.

Hymenoptera, 9: Apidæ, 4; Formicidæ, 1; Vespidæ, 1; Andrenidæ, 2; Tenthredinidæ, 1.

Lepidoptera, 3: Arctiidæ, 2; Noctuidæ, 1.

Trichoptera, 2: Phryganeidæ, 2.

Neuroptera, 2: Chrysopidæ, 2.

Orthoptera, 1: Blattidæ, 1.

Arachnida, 1: (Lycosidæ?)

IDENTIFIED SPECIES.

NAME.	FIRST COLLECTED.	DOMINANT.	LAST COLLECTED.
COLEOPTERA			
Aphodius fimetarius	April 14–21	—	May
Hippodamia 13-punctata	25	—	12
Hippodamia parenthesis	25	—	2
Hippodamia convergens	25	—	2
Coccinella sanguinea	25	—	31
Cyllene pictus	May 2	—	—
Necrophorus marginatus	2	—	—
Coccinella 9-notata	2	—	31
Chrysomela elegans	2	2	31
Anatis 15-punctata	2	—	31
Agonoderus pallipes	2	—	23
Casnonia pennsylvanica	2	—	16
Drasterias elegans	2	—	12
Disonycha triangularis	2	—	—
Megilla maculata	12	—	27
Diabrottica vittata	12	12	16
Diabrottica 12-punctata	12	—	—
Leptinotarsa 10-lineata	12	27	31
Calosoma scrutator	12	—	31
Calosoma wilcoxii	12	—	31
Elaphrus ruscarius	12	—	—
Platynus sp.?	12	—	16
Galerita janus	16	—	23
Hydrophilus triangularis	16	—	31
Lucanus dama	23	—	27
Calosoma calidum	23	—	31
Euphoria inda	23	—	—
Phymatodes sp.?	23	—	—
Geopinus incrassatus	23	—	—
Lachnosterna sp.?	27	—	—
Cotalpa lanigera	27	—	—
Sphenophorus sp.?	27	—	—
Ligyrus gibbosus	31	—	—
Coptocycla aurichalcea	31	—	—
HYMENOPTERA			
Lasius brunneus	April 15–21+	—	—
Polistes variatus	May 2	—	16
Prosopis sp.?	2	—	—
Augochlora sp.?	2	—	—
Bombus sp.?	12	—	27
Anthophora sp.?	27	—	—
Nomada sp.?	27	—	—

IDENTIFIED SPECIES (*Continued*).

NAME.	FIRST COLLECTED.	DOMINANT.	LAST COLLECTED.
DIPTERA			
Syrphus torvos (?)	April 25	—	May 16
Lucilia cæsar	28	—	31
Scarcophagus georgiana.	May 23 on?	—	—
HEMIPTERA			
Oncopeltus fasciatus	May 2	—	—
Benacus griseus	16	—	—
LEPIDOPTERA			
Estigmene acræ (?)	May 27	—	—
Eyprepia (?)	27	—	—
ARACHNIDA			
Present throughout			

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STUDIES OF LOCALIZED STAGES OF GROWTH IN SOME COMMON NEW ENGLAND PLANTS.

JOSEPH A. CUSHMAN.

In the following are given some of the stages in detail found in a few of our common plants, and some general notes which may be safely drawn, and which may be useful in studying plants from this point of view. The cases given are not chosen as particularly striking ones, but are such as would come naturally under the notice of any one. In a following paper the writer hopes to present more striking examples from some of the less generally known plants now in the Botanic Gardens of Harvard University. The few given, however, will show the truth of the principle involved as well as more striking ones.

In a paper by Robert T. Jackson, "Localized Stages in Development of Plants and Animals," *Memoirs Boston Society of Natural History*, Vol. V, No. 4, 1899, this principle was worked out and applied to plants. It was there applied to shoots and various growths of trees almost exclusively. It is in the spirit of that paper that I have attempted this one, giving the results of my study of plants from this point of view. My thanks are due to Dr. Jackson for reading this in manuscript and for many suggestions.

The new point intended to be brought out here is the application of the principle of localized stages to the early spring growth of herbaceous plants. These are adult plants, not young plants or seedlings. The principle is also applied to the stages immediately preceding the flower.

The principle of localized stages in development, to quote from the above paper, is that, "throughout the life of the

individual, stages may be found in localized parts, which are similar to stages found in the young and the equivalent of which are to be sought in the adults of ancestral groups." This principle may be well demonstrated in a greater or less completeness in each of the following examples.

Viola pedata L. (Bird's-Foot Violet).

Under this species Gray's *Manual* gives, "leaves all 3–5-divided, or at the earliest only parted, the lateral divisions 2–3-parted, all linear or narrowly spatulate, sometimes 2–3-toothed or cut at the apex," thus recognizing the fact of the differences in the leaves but with no significance of the various forms or connection between them.

On April 18, 1902, a study was made of the leaves of this species in adult plants which were then well started. Among the larger and stronger plants it was found that the earliest leaves went back in the accompanying series usually to Pl. I, Figs. 10 or 11. After further search plants were found with the leaves on the outside of the rosette, similar to Figs. 9, 8, or 7. Noticing that the smaller plants seemed to be simpler or more primitive, attention was turned to them, and some small ones were found with the outside leaves going back to Fig. 6, and the smallest to Figs. 5 or 4. These were along a woods road in a somewhat dry, sandy place. In the middle of this road, where there was very little vegetation, were found plants evidently very young and weak, with the result that some were obtained with the simple leaves shown in Figs. 3, 2, and 1. That these were not seedlings was shown by the rootstock. They were probably weak plants of the preceding year.

In nearly all the stages shown many specimens were obtained of each stage, and in all cases enough to warrant the form as not abnormal. Where the outer leaves were most primitive the more complete were the stages before the typical leaves were produced in the center. Seedlings of this plant were not obtained, but the earliest of the stages given are very similar to corresponding ones of *Viola tricolor* L. in both young and adult. Later stages would naturally be specific. The seedling

would probably not repeat all of the stages given here, but the majority of them. The data here being fairly complete will be referred to again later.

Chelidonium majus L. (Celandine).

Seedlings of this plant were found at Arlington Heights in May, among the adult plants, and afforded a very convenient opportunity to study the relations of the two.

The leaves of the seedling after the cotyledons are developed as follows (Pl. II, Figs. 1, 2): First leaf usually slightly trilobed and trinerved; second leaf usually decidedly five-lobed and five-nerved; the third leaf is decidedly trilobed, with the median lobe notched, lateral ones entire or with one notch. From the third on, the trilobed character persists for a short period, the leaves becoming, later, three-pinnate, five-pinnate, and so on.

In comparing this with the first leaves of the adult plant when it starts from the ground in the spring, a striking likeness is at once noted. In the plant shown in Pl. II, Fig. 3, the first leaf is exactly comparable to the second leaf of the seedling, and the second to the third of the seedling. The third leaf is like the three-parted one of the seedling, the fourth similar. The fifth is five-pinnate, and so on. In all cases where the first formed leaves were found on the plant, these comparisons were found to be true. It was especially noticeable in the plants found at Arlington Heights, which were on a sloping gravel bank with poorer nourishment than in other cases noticed in Cambridge. In this plant the early development in spring growth representing localized stages, and in the seedling representing direct development, not only show great similarity but may be exactly compared stage by stage.

Aquilegia canadensis L. (Wild Columbine).

The seedlings of this plant have the first nepionic leaves typically trifoliolate, with the terminal leaflet having two well-marked notches and each of the lateral leaflets one less-marked notch

on the lower side. By raising a number of the seedlings of this plant there was found a marked variation from the typical form. In two cases the first nepionic leaves were trifoliolate, but both the terminal and lateral leaflets were entire, no sign of notches being present. The second leaves in the two cases given were typical of the first of the other seedlings, thus showing that these two individuals were less accelerated in development than the others. These two repeated the character of a trifoliolate leaf with entire edges, which is usually dropped out in the development of the seedling.

By comparison with the early spring growth of adult plants, the first leaves of some weaker individuals were trifoliolate and entire, as are those of the two seedlings noted above. This is, then, not an accidental variation, but a true stage, which in the seedling is usually skipped by acceleration of development, and rarely appears there. In several cases the first leaves were like the typical first leaves of the seedling. This, then, shows two rates of acceleration, as it takes one longer to arrive at a certain stage than it does another.

A striking similarity is noticed in the leaves immediately preceding the flower. At the base of the flower stalk the leaves are normal, but higher up the number of leaflets is reduced until, a short distance below the flower, there appears a trifoliolate leaf with notches varying considerably, some being like the typical first nepionic leaf of the seedling, others variously notched. The majority, however, are like the seedling. The next leaf above usually drops out the notches and has an entire outline. This can be directly compared to the earlier stage noted in two seedlings and in the average simple leaves of spring growth of the adult plant. Just beneath the flower is often found a single leaf, entire and exactly comparable to the terminal leaflet of the trifoliolate leaf. Thus at the flower the leaves retrace the steps which they went through in the early growth of the plant and in the reverse order. This last stage — the simple leaf below the flower — is more primitive than anything that is found in the seedling, showing that localized stages may be used to fill in the steps which are crowded out by the acceleration of development in the seedling.

Ranunculus acris L. (Buttercup).

This species has the typical leaves three-divided, and the divisions considerably cleft and toothed, but the seedling starts off with fairly simple nepionic leaves (Pl. II, Fig. 4). Comparing the localized stages shown in the early spring growth with the direct development of the seedling, a great similarity is again noted. The plants were well started when observed, and weak growths had to be largely depended upon to show the stages. Pl. II, Fig. 5, shows a leaf of which one-half is comparable to the first nepionic leaf of the seedling. The other half is like the second nepionic. Here, then, is a leaf showing an acceleration of development in its two halves, — the half with two lobes being more accelerated than the other. This is often noted in compound leaves which are pinnate, — there being fewer leaflets on one side than on the other, — but is less often definitely shown in simple leaves. A first leaf of spring growth is figured, Pl. II, Fig. 6, which is comparable to the second nepionic leaf. The steps in complication of the lobes and nervation are shown in Figs. 7–9, and the seedling in its later development passes through similar stages.

Beneath the flower the leaves become more simple usually by four distinctly reverse, but often varied, steps. The lower one of the four has about the same number of divisions as Fig. 8, but is drawn out into linear divisions. Higher up is a leaf that may be compared to the second nepionic of the seedling, or to the leaf figured in localized development (Fig. 5), in that it has five lobes. It is, like the preceding, deeply cut and elongated. Above this is a three-lobed leaf of the same character and in its lobing comparable to the first nepionic leaf of the seedling. Just beneath the flower is usually a simple, elongated leaf, showing once more a localized stage in the adult plant more primitive than any of the stages shown in the direct development of the seedling.

This species is one which is usually well developed in the early spring, and these earlier and weaker forms are hard to find without careful searching. The first formed leaves quickly dry, curl, and then drop off.

Spiræa salicifolia L. (Common Meadowsweet).

This is not herbaceous, and the stem, unlike the others before noted, is woody, and the early spring growth is from the buds at the sides as well as new shoots from the ground. Such a lateral growth is figured, Pl. III, Fig. 3. The first leaf indications are mere bracts. The first of what may be called the true leaves is entire, lanceolate, with a simple median vein. This is the first in the series and the simplest. This seems to be a case like that noted under *Aquilegia canadensis*, where a stage is found simpler than that of the ordinary seedling first stage, as the first nepionic leaves of two species of Spiræa as figured by Lubbock are like No. 2 of Fig. 3. The second leaf is cuneate and tridentate, trinerved, the broadest part near the tip. The third leaf is five-dentate like the second nepionic leaf figured by Lubbock. The complexity of dentations increases and the broadest portion of the leaf moves from near the tip to near the base. The leaves become doubly serrate, but the tip holds the form of the second leaf given, throughout.

The spire formed by the flowers usually has one or more of the lower branches with more leaves than flowers, and here the reversal of the stages is well shown. Near the main stalk the leaves are typical, but moving distally along the branch they will be seen to lose little by little in the number of dentations. This keeps on until there are but three, as in the second leaf figured, and then there are several simple ones. The wedge shape, with its broadest part toward the tip, is not reassumed, but in dentations the stages are exactly reversed beneath the flowers.

Tanacetum vulgare L. (Tansy).

As far as was found, the seedling of this species has not been published, and therefore it is given in a little more detail than the others (Pl. III, Figs. 4 and 5).

Cotyledons glabrous, subfleshy; lamina oblong, obtuse, sessile. The first nepionic leaves are paired and vary considerably. As a whole they are spatulate, obtuse, and may be distally

toothed. Ten seedlings in a single pot were compared as to their first nepionic leaves as follows:

Both first leaves simple	2
One simple, one one-notched	1
One simple, one two-notched	1
Both one-notched	2
One one-notched, one two-notched	1
Both two-notched	3
	10

This crude table is enough to show the individual variation of seedlings under the laws of acceleration of development and the consequent necessity of making sure of the typical stages.

The second pair of nepionic leaves have typically two lateral teeth on each side in some cases, with more complicated forms than this, but even in this case, so far as seen, only one of the pair has the more complicated form, the other being typical. The midrib begins to be distinct.

The next leaves are quite dissected and begin to decidedly resemble the typical adult leaf. It may have in the third pair of nepionic leaves from three to seven or more lateral teeth on each side, and these may also be divided or notched.

Among the adult plants at the very base in the first spring growth, leaves may be found which repeat many of the simpler conditions. Fig. 6 is decidedly three-parted, much as the first nepionic leaf in many ways, but less strikingly so than Fig. 7, which is quite like the second nepionic leaf of the seedling. Figs. 8 and 9 are like later seedling stages. All of these leaves are from the base of fresh spring growths.

The flowers of this plant are in a dense corymb, each portion of which comes from the axil of a leaf. The leaves in the upper part become inconspicuous, but repeat, however, many of the characters seen in the seedling and in the reverse order, those immediately below the upper heads being like the first and second nepionic leaves in the number of teeth and general character. This is exactly comparable to the principles of senescence of the late Professor Hyatt, stages occurring in the old age of the individual corresponding to stages passed through

in nepionic development, but in the reverse order of succession. He has shown this at length in his "Genesis of the Arietidæ," published in part as a paper of the Museum of Comparative Zoölogy of Cambridge, and as No. 673 of the *Smithsonian Contributions*. It is given more simply and concisely in a paper, "Cycle in the Life of the Individual (Ontogeny) and in the Evolution of its Own Group (Phylogeny)," *Proceedings of the American Academy of Arts and Sciences*, Vol. XXXII, No. 10, as well as in other papers. This case seems to be comparable in that it is a failure to develop the full characters of an earlier adult condition, due to the strength of the plant going into the production of flower and seed instead of developing leaves. The tip of the leaf in all cases repeats the tridentate character of the first nepionic leaf, both in the tip of the leaf proper and in the tips of all the divisions.

Viola tricolor L. (Pansy).

This plant is very seldom a perennial, but often comes up from the rootstock the second year. Such plants are easily obtained, and so exactly do the stages compare with the seedling that were it not for the rootstock and the absence of cotyledons the two might be easily mixed. The seedling is figured by Lubbock, *Seedlings* (1892), and in that and in seedlings examined the stages were exceedingly like those of the early spring growth from a rootstock. The reversal of these stages beneath the flower is seen with varying definiteness. The old single form known as heart's-ease seems to show this best. The number of notches decreases and the leaves return to the forms seen in the beginning, those directly beneath the flower being exactly like the first of the spring growth of the adult and the first nepionic (Pl. III, Figs. 1 and 2).

Rosa rubiginosa L. (Sweet Brier).

In this plant, perhaps, of those given here, the stages are most easily and completely seen. The seedling varies, having the first nepionic leaf single as in Pl. IV, Fig. 1, or it may be trifoliolate like the second leaf of Fig. 1, as in Fig. 2; in each case the

second nepionic leaf is trifoliolate, as well as several following ones. Then the number of leaflets increases to five, and in the full-grown plant becomes seven. In the first spring growth the first leaf, especially upon the lower or weaker parts of the plant, is very often trifoliolate, like the second nepionic leaf in all cases and like the first in some. In some cases, however, a simple leaf may be found, but rarely. When it does appear, it may be compared to the simple leaf seen in the first nepionic leaf of Fig. 1. After this trifoliolate leaf in the spring growth of the adult is one of five leaflets, then usually five leaflets until the flowering stage. Then the number drops by the same steps that it increases, but in the reverse order. Going toward the flower, leaves are encountered with five, then three leaflets, until finally just below the flower there is a simple one. Here, then, are repeated the exact steps by actual count of the stages of the seedling in the early spring growth, and as exact a reversal of the same stages beneath the flower. The same is true of *Rosa lucida* and other species (Pl. IV, Fig. 3).

Although these examples given might be multiplied almost without number, they will do to illustrate several general principles which may be drawn from them. The various conditions are more or less combined in any actual case, as they often are in such problems, but the effect of each may be noted nevertheless.

First, the relation between the occurrence of the earliest stages and the age of the plant. The plant coming up the second year, other conditions being the same, seems to be more primitive in its first characters than older and stronger plants. It therefore repeats more stages in arriving at the typical form than older individuals. The case of *Viola pedata* illustrated this, the young plants of the preceding year being the ones in which the earliest stages were noticed. In some plants, however, the typical leaf of the species is not reached for several years. The young trees of *Carya alba* Nutt., the shagbark hickory, have when very young — the second year, for example — only single and trifoliolate leaves, and it is some time before the number rises to five leaflets. The typical one of seven leaflets does not appear until quite a late period.

Weak individuals are more apt to show earlier stages than are more vigorous plants. They represent plants which are less accelerated in their development, not attaining the characters usual in plants of their age and other conditions. This is true whether the whole is weak or whether the growth comes from adventitious or weaker buds. The same is true of plants injured by outside agencies; for example, when the leaves are stripped by insects and a later growth put out from the weaker buds, before undeveloped.

Soil and moisture conditions come into play here. The poor sandy soil and lack of moisture mentioned in the first two examples given, shows its effect by producing weak individuals. Plants in poor, dry soil often repeat stages not seen in strong, vigorous plants in other places.

In studying these localized stages, especially in the early spring growth of herbaceous plants, some things must be especially looked out for. The first leaves which appear are often very small and would be overlooked unless they were being sought for especially. Many of these plants which start very early in the spring adopt the rosette form, and these first early leaves are hidden under the later ones. These small early leaves are usually delicate and soon wither and drop off, especially in rapid growth or where the rosette form is adopted. For these reasons many plants, even in early spring, may show no traces of the very early stages which they would have shown if examined a short time before. The surest way to find these first leaves is to notice where the plant is growing the year before and mark it in some way so that it may be looked for the following spring.

As shown, seedlings may vary considerably, and also these stages, so that to avoid errors there is necessary a knowledge of the seedling or allied ones, and of ancestral forms. By a close study of these localized stages and their variations — within limits — in many individuals, steps in the phylogeny may be determined which it would be impossible to fix in any other way. Many stages may be found in this way that in the acceleration of the seedling are crowded out of the record preserved there.

Coupled with a knowledge of the seedlings and of ancestral forms these localized stages may be used to great advantage in determining not only the phylogeny in a broad way, but the relations, especially to plants in the same genus or family. By comparing the character of the stages repeated and the acceleration with which they are gone through with, something may be learned of the position of the species in relation to others within the genus, according to the general principle that greater acceleration of development means a higher form. Comparison of seedlings of different species may also determine this to a considerable extent, but many seedlings of each species should be compared to get the relation of the variation. Thus from the seedlings of various species of Aquilegia raised and compared, a definite relation was noticed in regard to the relative difference in time of appearance of the same stage in different species. In this way localized stages, together with a comparative study of seedlings, may be made to yield profitable results in a field where there is otherwise very little data to depend on.

EXPLANATION OF PLATES.

Leaves are numbered in order of their development, except below the flower,—there, in the reverse order. c = cotyledons.

Figures drawn from nature by the writer.

PLATE I.

Viola pedata L.

FIG. 1. First leaf of spring growth of plant one year old. Found in middle of old woods road-dry soil. × 1½.

FIGS. 2, 3. Second and third leaves of same plant. × 1.

FIGS. 4, 5. First leaves of spring growth of plants found at side of same road in slightly more favorable conditions. Plants small and evidently weak. × 1.

FIG. 6. First leaf of slightly stronger plant in same place. × 1.

FIGS. 7–9. First leaves of decidedly stronger individuals in better situations. × 1.

FIGS. 10, 11. First leaves of thrifty plants of more than one year's growth. × 1.

FIGS. 12–14. Later leaves of same plants. × 1.

FIG. 15. Most complex leaf noted in strongest and best developed plant. × 1.

PLATE I.

PLATE II.

(All natural size.)

Chelidonium majus L.

FIG. 1. Seedling showing cotyledons and first and second nepionic leaves.

FIG. 2. Seedling as preceding, but showing also third nepionic leaf.

FIG. 3. Leaves of early spring growth. In sandy soil at Arlington Heights, Mass. 4th, 6th, and 8th leaves not shown — each like the one immediately preceding.

Ranunculus acris L.

FIG. 4. Seedling showing cotyledons and 1st, 2d, and 3d nepionic leaves.

FIG. 5. Simplest leaf found in an adult plant; first leaf of spring growth of weak plant. Two halves of leaf show difference in acceleration of development. Compare right half with 1 of Fig. 4; left half with 2 of same figure.

FIG. 6. First leaf of spring growth in weak plant. Compare with 2, Fig. 4.

FIG. 7. First spring growth of a weak shoot. Compare with 2, 3, Fig. 4.

FIGS. 8, 9. Later stages in adult plant and complication of the network of veins.

FIG. 10. Typical adult leaf.

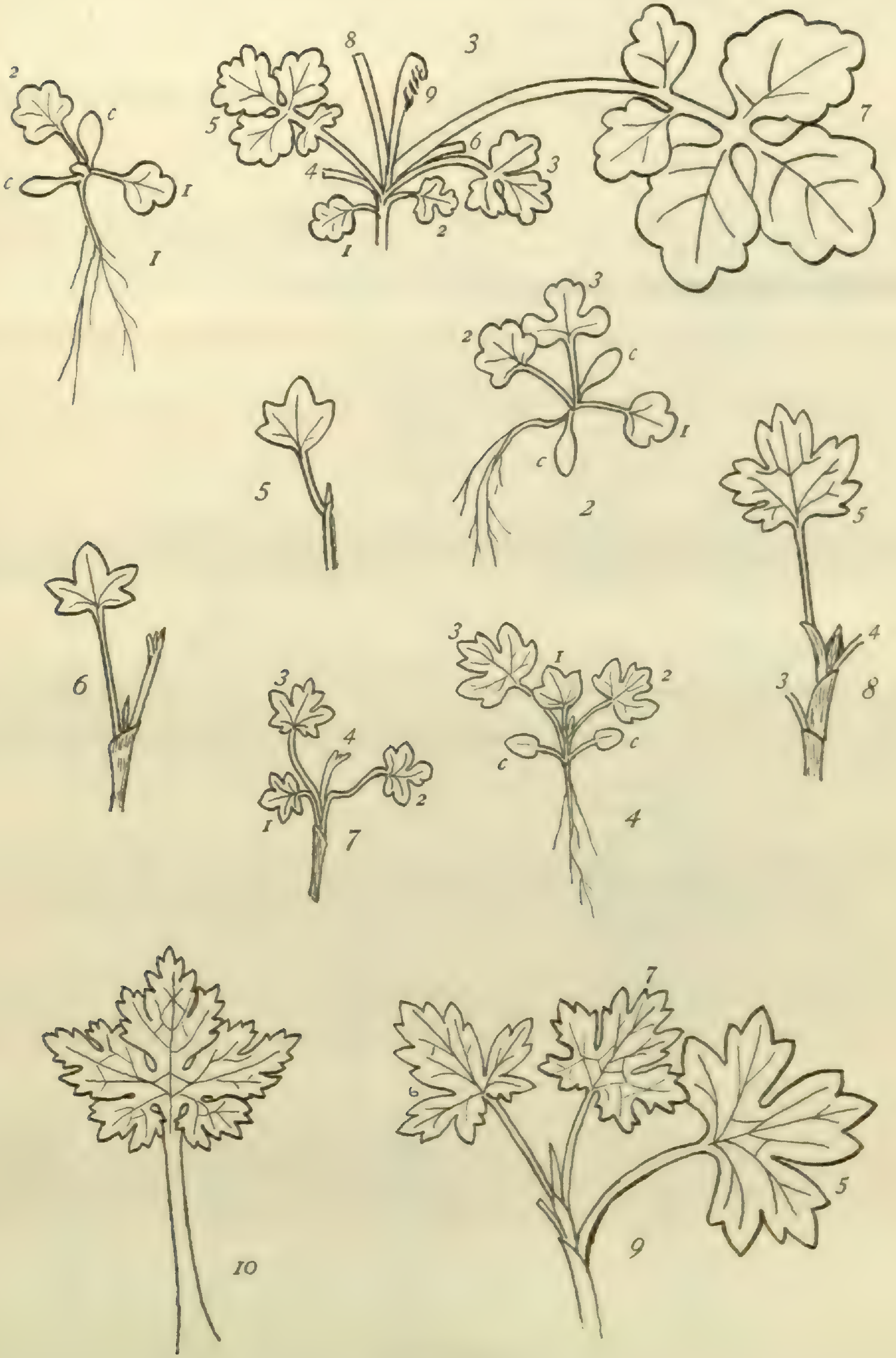

PLATE II.

PLATE III.

(All natural size.)

Viola tricolor L.

FIG. 1. Stages in early spring growth from rootstock of preceding year.

FIG. 2. Stages below flower. Numbered in reverse order of development for comparison with preceding.

Spiræa salicifolia L.

FIG. 3. Growth from lateral bud on plant of previous year. Bract-like leaves at base not numbered.

Tanacetum vulgare L.

FIG. 4. Seedling with cotyledons and typical pair of first nepionic leaves.

FIG. 5. Seedling with second pair of nepionic leaves also.

FIGS. 6–10. Leaves found near the base of adult plants in spring growth. Compare 6 and 7 with 1 and 2 of Figs. 4, 5.

FIG. 11. Simplest leaf to be found after early spring growth has withered. Very complex when compared with Figs. 6–9.

PLATE III.

PLATE IV.

(All natural size.)

Rosa rubiginosa L.

FIG. 1. Seedling showing cotyledons, and simple first and trifoliolate second nepionic leaves.

FIG. 2. Seedling with both first and second nepionic leaves trifoliolate.

Rosa lucida L.

FIG. 3. Stages from first leaf of spring growth, 1, to flowering stage, 12.

PLATE IV.

PLATE V.

Aquilegia canadensis L.

FIG. 1. Seedling with first nepionic leaf simple in outline, second normal. × 1.

FIG. 2. Seedling with normal form of first and second nepionic leaves. × 1.

FIG. 3. Stages in early spring growth from ground. Compare with seedlings and Fig. 4. × ½.

FIG. 4. Stages below flower, partly diagrammatic in apparent crowding, but each leaf in its relative position and shape. Numbered in reverse order for comparison with Fig. 3 and seedlings.

PLATE V.

SYNOPSES OF NORTH-AMERICAN INVERTEBRATES.

XII. The Trematodes.

PART II.[1] — *THE ASPIDOCOTYLEA AND THE MALACOCOTYLEA, OR DIGENETIC FORMS.*

H. S. PRATT.

The following are the families, subfamilies, and genera of the suborders Aspidocotylea and Malacocotylea, as arranged by Braun, Fischoeder, Looss, Lühe, Monticelli, Stiles and Hassall, and others:

Order. — Trematoda Rud.

Suborder II. Aspidocotylea Mont.

Family. Aspidobothridæ Burm.

Genera: Macraspis, Stichocotyle, Aspidocotylus, Platyaspis, Cotylaspis, Cotylogaster, Aspidogaster, Lophotaspis.

Suborder III. Malacocotylea Mont.

Family I. Paramphistomidæ Fisch.

Subfamily I. Paramphistominæ Fisch.

Genera: Gastrothylax, Paramphistomum, Stephanopharynx.

Subfamily II. Cladorchinæ Fisch.

Genera: Gastrodiscus, Homologaster, Diplodiscus, Cladorchis, Chiorchis.
Related genus: Balanorchis.

Family II. Fasciolidæ Rail.

Subfamily I. Fasciolinæ S. et H.

Genera: Fasciola, Fasciolopsis, Campula.
Related genera: Pleorchis, Paragonimus.

Subfamily II. Omphalometrinæ Lss.

Genera: Omphalometra, Cathæmasia.

[1] Part I appeared in the *American Naturalist*, vol. xxxiv (August, 1900), p. 645. The figures illustrating Part II will appear in the continuation, in the December number of the *American Naturalist*.

Subfamily III. Opisthorchiinæ Lss.

Genera: Opisthorchis, Holometra, Metorchis.
Related genus: Podocotyle.

Subfamily IV. Telorchiinæ Lss.

Genera: Telorchis, Orchidasmus.
Related genus: Deropristis.

Subfamily V. Echinostominæ Lss.

Genera: Echinostoma, Stephanochasmus. Dihemistephanus, Stephanoprora.
Related genus: Rhopalias.

Subfamily VI. Psilostominæ Pratt.

Genera: Psilostomum, Crepidastomum, Rhytidodes, Allocreadium, Calycodes, Azygia, Halicometra, Cotylotretus.
Related genera: Ptychogonimus, Orchipedum.

Subfamily VII. Anisocœlinæ Lss.

Genera: Anisocœlium, Anisogaster.

Subfamily VIII. Centrocestinæ Lss.

Genera: Centrocestus, Ascocotyle.
Related genera: Acanthochasmus, Anoiktastoma.

Subfamily IX. Cotylogoniminæ Pratt.

Genera: Cotylogonimus, Cryptocotyle.

Subfamily X. Philophthalminæ Lss.

Genera: Philophthalmus, Pygorchis.

Subfamily XI. Plagiorchiinæ Pratt.

Genera: Opisthioglyphe, Plagiorchis.
Related genera: Glossidium, Endiotrema, Pachypsolus.

Subfamily XII. Reniferinæ Pratt.

Genera: Styphlodora, Ochetosoma, Renifer, Oistosomum, Astiotrema.

Subfamily XIII. Bunoderinæ Pratt.

Genera: Bunodera, Tergestia.

Subfamily XIV. Haplometrinæ Pratt.

Genera: Haplometra, Hæmatolœchus, Ostiolum, Macrodera.
Related genera: Opisthogonimus, Asymphylodora.

Subfamily XV. Anaporrhutinæ Lss.

Genera: Anaporrhutum, Plesiorchorus.
Related genus: Callodistomum.

Subfamily XVI. Gorgoderinæ Lss.

Genera: Phyllodistomum, Gorgodera.

Subfamily XVII. Microphallinæ Ward.

Genera: Microphallus, Levinsenella.

Subfamily XVIII. Brachycœliinæ Lss.

Genera: Phaneropsolus, Lecithodendrium, Pycnoporus, Brachycœlium.
Related genera: Cymatocarpus, Brandesia.

Subfamily XIX. Pleurogenetinæ Lss.

Genera: Prosotocus, Pleurogenes, Gymnophallus, Lepidophyllum.

Subfamily XX. Cephalogoniminæ Lss.

Genera: Cephalogonimus, Emoleptalea, Prosthogonimus.
Related genus: Stromylotrema.

Subfamily XXI. Dicrocœliinæ Lss.

Genera: Dicrocœlium, Lyperosomum, Athesmia.
Related genera: Eumegacetes, Anchitrema.

Subfamily XXII. Hemiurinæ Lss.

Genera: Hemiurus, Lecithocladium, Pronopyge, Lecithochirium, Lecithaster, Liopyge, Derogenes.

Subfamily XXIII. Syncœliinæ Lss.

Genera: Progonus, Syncœlium, Otiotrema.
Related genus: Halipegus, Accacœlium, Eurycœlum.

Subfamily XXIV. Harmostominæ Lss.

Genera: Harmostomum, Ityogonimus, Glaphyrostomium, Scaphiostomum.

Subfamily XXV. Urogoniminæ Lss.

Genera: Urorygma, Urogonimus, Urotocus, Urotrema.

Subfamily XXVI. Zoögoninæ Odh.

Genera: Zoögonus, Zoögonoides.

Subfamily XXVII. Clinostominæ Pratt.

Genera: Clinostomum, Nephrocephalus.
Additional genera: Sperostoma, Microlistrum, Mesotretes, Hapalometra, Distomum.

Family III. Schistosomidæ Lss.

Genera: Schistosoma, Bilharziella, Kœllikeria.

Family IV. Holostomidæ Brds.

Subfamily I. Cyathocotylinæ Pratt.

Genus: Cyathocotyle.

Subfamily II. Diplostominæ Brds.

Genera: Diplostomum, Polycotyle.

Subfamily III. Hemistominæ Brds.

Genus: Hemistomum.

Subfamily IV. Holostominæ Brds.

Genus: Holostomum.

Family V. Gasterostomidæ Brn.

Genus: Gasterostomum.

Family VI. Didymozoönidæ Mont.

Genera: Didymozoön, Nematobothrium.

Family VII. Monostomidæ Mont.

Subfamily I. Microscaphidiinæ Lss.

Genera: Microscaphidium, Deuterobaris.

Subfamily II. Pronocephalinæ Lss.

Genera: Pronocephalus, Pleurogonius, Glyphicephalus, Adenogaster, Cricocephalus, Pyelosomum.

Related genus: Charaxicephalus.

Subfamily III. Haplorchidinæ Lss.

Genera: Haplorchis, Galactosomum.

Additional genera: Opisthotrema, Cyclocœlum, Notocotylus, Ogmogaster, Stictodora, Mesometra, Monostomum.

ORDER. — TREMATODA RUD.

Small parasitic flatworms, with unsegmented, flattened or cylindrical, unciliated bodies, with usually anterior mouth opening and bifurcate intestine, and without anal opening, which attach themselves to their hosts by means of suckers, or hooks, or both.

KEY TO THE SUBORDERS.

A_1. Usually ectoparasitic trematodes living upon the external surface or the gills, or in the mouth or cloaca of aquatic animals (except genus Polystoma), to which they attach themselves by means of suckers, or hooks, or both; suckers, when present, are usually near either one or both ends of the body; when at the anterior end, in most cases, a single pair is present; when at the posterior end, in most cases, one or more pairs are present, or, in their place, a sucking disk . . . . Heterocotylea Mont.

A_2. Endoparasitic trematodes which attach themselves to their hosts either by means of one or more median (unpaired) suckers or a large ventral sucking disk; hooks never present.

B_1. Either a large ventral sucking disk or a mid-ventral row of suckers present; no oral sucker; intestine not bifurcate (except possibly Aspidocotylus) . . . . . . Aspidocotylea Mont.

B_2. Either one or two or, in a few cases, more than two median suckers present; an oral sucker invariably present (except Gasterostomum); intestine, except in rare cases, bifurcate
Malacocotylea Mont.

Key to the Genera of the Suborder Aspidocotylea and the Family Aspidobothridæ.

a_1. A single mid-ventral row of suckers present, extending nearly or quite the length of the body, which is elongate and cylindrical.

b_1. Suckers contiguous and confluent, on a distinct ridge of the body: one testis: in gall bladder of Chimæra
Macraspis Olss. (Fig. 1) (55, 66)[1]

b_2. Suckers not contiguous and not on a ridge; two testes: in gall passages of skates (as adults) and in cysts in the end-intestine of lobsters (as larvæ) . Stichocotyle Cunn. (Fig. 2) (62, 68, 66)

a_2. Very large circular or oval sucking disk present.

b_1. Sucking disk circular, containing a number of small round sucking pits; intestine possibly bifurcate: in the intestine of fresh-water fish . . . . Aspidocotylus Dies. (Fig. 3) (58, 66)

b_2. Sucking disk circular or elliptical and containing three or four longitudinal rows of more or less rectangular depressions separated from one another by ridges.

c_1. Sucking disk with three rows of depressions.

d_1. Sucking disk irregularly circular or elliptical, with crenulate border and with transversely elongated depressions; one testis.

e_1. Number of depressions about twenty-five: marginal sense organs and eyes absent: in intestine of chelonians . . . . Platyaspis Mont. (Fig. 4) (58, 66)

e_2. Number of depressions about twenty-nine: twenty marginal sense organs and two eyes present: in mantle chamber of fresh-water mussels
Cotylaspis Leidy (Fig. 5) (22, 17, 66)

d_2. Sucking disk elliptical, with very long transversely elongated median depressions and small round lateral ones: two testes; marginal sense organs: in the intestine of fish
Cotylogaster Mont. (Fig. 6) (58, 66)

[1] The numbers in parentheses following the name of a genus or a species refer to the publications in the bibliography in which detailed descriptions of it may be found.

c_2. Sucking disk with four rows of depressions; one testis; marginal sense organs.

d_1. Number of depressions seventy-seven; small protrusile tentacle-like sacks at the corners of the ridges: in the stomach of sea turtles . . . . Lophotaspis Lss. (49)

d_2. Number of depressions 64–120; no protrusile sacs: in fresh-water mussels

Aspidogaster v. Baer (Fig. 7) (58, 66)

KEY TO THE FAMILIES, SUBFAMILIES, AND GENERA OF THE SUBORDER MALACOCOTYLEA.

a_3. But one sucker present (see p. 908).

a_2. Two suckers present, the oral sucker and the acetabulum, together with a large variously constructed ventral projection or disk of use in attachment (see p. 908).

a_1. Two suckers present, the oral sucker and the acetabulum, the latter either at the posterior end or in the mid-ventral surface; no other organ of attachment present.

b_1. Acetabulum at posterior end, either terminal or subterminal

Family I. Paramphistomidæ

c_1. Lateral pharyngeal pockets not present; cirrus sac absent

Subfamily I. Paramphistominæ

d_1. Genital pore opens near oral sucker into a large pouch; acetabulum terminal; body cylindrical: in herbivores

Gastrothylax Poir. (Fig. 8) (11)

d_2. Genital pouch not present; testes near center of body; ovary behind them: usually in herbivores.

e_1. Pharynx with ring-shaped projection near its hinder end; intestine long and serpentine

Stephanopharynx Fisch. (11)

e_2. Pharynx without ring-shaped projection; body conical: acetabulum subterminal

Paramphistomum Fisch. (Fig. 9) (11)

c_2. Lateral pharyngeal pockets present; cirrus sac present

Subfamily II. Cladorchinæ

d_1. Ventral surface with numerous papillæ.

e_1. Acetabulum minute and subterminal; body made up of two portions, a slender anterior portion and a very broad, disklike posterior portion, which contains numerous papillæ on its concave ventral surface: in intestines of herbivores Gastrodiscus Leuck. (Fig. 10) (11)

e_2. Acetabulum large and subterminal; entire ventral surface covered with papillæ: in intestine of mammals

Homologaster Poir. (Fig. 11) (11)

d_2. No ventral papillæ present.

e_1. Testes simple, not lobate or dendritic.

f_1. Acetabulum terminal with excretory pore in its center; testes often fused to form a single body: in the rectum of amphibians

Diplodiscus Dies. (Fig. 12) (41)

f_2. Excretory pore not in acetabulum; testes in extreme hinder part of body with ovary in front of one of them; genital pore with a muscular fold around it; very small worms: in the stomach of herbivores . . . . . . Balanorchis Fisch. (11)

e_2. Testes dendritic, near center of body.

f_1. Intestine long and serpentine; no bulblike widening of œsophagus; ovary near acetabulum: in mammals . . . . . Cladorchis Fisch. (11)

f_2. Intestine straight; œsophagus with bulblike widening; ovary behind testes, which lie one behind the other and are each cross shaped

Chiorchis Fisch. (11)

b_2. Acetabulum in the mid-ventral surface, but not at posterior end.

c_1. Worms hermaphroditic . . . . . Family II. Fasciolidæ

d_3. Ovary between testes (see p. 906).

d_2. Ovary behind testes (see p. 903).

d_1. Ovary in front of testes.

e_1. Uterus does not extend back of testes.

f_1. Intestinal cœca long and with lateral projections; yolk glands very voluminous: usually in the liver or lungs of mammals Subfamily I. Fasciolinæ

g_1. Worms of large size, broad and leaf-like; acetabulum near anterior end; intestinal cœca, testes, and ovary profusely branched.

h_1. Body elongate; anterior end conical and more or less set off from remainder of worm . Fasciola L. (Fig. 13) (44, 83)

h_2. Body circular

Fasciolopsis Lss. (Fig. 14) (44)

g_2. Worms not of large size; lateral branches of intestinal cœca short and few.

h_1. Testes two, one behind the other: in liver of Cetacea

Campula Cob. (Fig. 15) (4, 86)

h_2. Testes numerous, in two longitudinal rows: intestinal cœca with but two branches, which pass anteriad: in fish

Pleorchis Rail. (Fig. 16) (86)

f_2. Intestinal cœca without lateral projections.

g_1. Genital pore immediately behind acetabulum (but not on a papilla); body thick and egg-shaped; intestinal cœca long; testes lobate, in same transverse plane; yolk glands very large; uterus very small, near acetabulum: in lungs of mammals
Paragonimus Brn. (Fig. 17) (87)

g_2. Genital pore in front or at left side of acetabulum or, if behind, on a papilla.

h_1. Yolk glands dendritic, *i.e.*, diffuse and not compact.

i_1. Either a ring of spines or two spiny, retractile tentacles at anterior end.

j_1. Testes in same transverse plane behind acetabulum; mouth surrounded by spines.

k_1. Testes and yolk glands near middle of body, which is broad Anoiktastoma Stoss. (Fig. 18) (44)

k_2. Testes and ovary at extreme hinder end of body: in small intestine of birds and mammals
Subfamily VIII. Centrocestinæ

l_1. Intestinal cœca long; œsophagus wanting; testes and yolk gland large
Centrocestus Lss. (Fig. 19) (44)

l_2. Intestinal cœca short, not reaching acetabulum; œsophagus long; a dorsal lip over mouth; oral sucker prolonged posteriorly into a long, blind sac Ascocotyle Lss. (Fig. 20) (44)

j_2. Testes one behind the other, not in same transverse plane.

k_1. Two spiny, retractile tentacles present, one on either side of mouth: in the opossum
Rhopalias S. et H. (Fig. 21) (86, 7)

k_2. Tentacles not present; body usually elongate and cylindrical; mouth surrounded by spines.

l_1. Testes and ovary close together in extreme hinder end of body; oral sucker large and surrounded by a single row of spines: in reptiles and fish
Acanthochasmus Lss. (Fig. 22) (44, 48)

l_2. Testes and ovary usually not all close together and not in extreme hinder part of body, although in posterior half.

m_1. Intestinal cœca do not reach to end of body and not of equal length; testes elongate; mouth surrounded by a single row of spines: in intestine of fish
Subfamily VII. Anisocœlinæ

n_1. Testes very small and elongate and in center of body; ovary lobate; uterus does not extend to end of intestinal cœca
Anisocœlium Lühe (Fig. 23) (52)

n_2. Testes elliptical, in hinder half of body; ovary spherical; uterus extends to end of body
Anisogaster Lss. (Fig. 24) (49)

m_2. Intestinal cœca extend to end of body, or nearly so, and are of equal length Subfamily V. Echinostominæ

n_1. Mouth surrounded by a single row of spines.

o_1. Oral spines set in a more or less reniform ridge and interrupted mid-ventrally
Echinostoma R. (Fig. 25) (44)

o_2. Oral spines not set in a ridge or interrupted ventrally; a number of unusually large spines just back of mouth: in crocodiles
Stephanoprora Odh. (71)

n_2. Mouth surrounded by a double row of spines.

o_1. Spines entirely surround mouth; long pre-pharynx present: in fish
Stephanochasmus Lss. (Fig. 26) (44, 48)

o_2. No spines on ventral side of mouth, but a little back of this is a group of short spines
Dihemistephanus Lss. (Fig. 27) (48)

i_2. Neither a ring of spines nor tentacles present at anterior end.

j_1. Testes two in number, one behind the other, often obliquely, but never in same transverse plane; body usually elongate.

k_1. Ovary separated from one or both testes by half the length of the body, the space being filled by the uterus; cirrus sac very long: in turtles . . . . Subfamily IV. Telorchiinæ

l_1. Both testes at extreme hinder end of body
Telorchis Lühe (Fig. 28) (50, 10)

l_2. One testis at extreme hinder end and one near ovary
Orchidasmus Lss. (Fig. 29) (44, 45)

k_2. Ovary not widely separated from testes; uterus usually in front of ovary.

l_1. Excretory vesicle Y-shaped, with very long stem, which winds between the testes; receptaculum seminis large; no cirrus sac: in the liver of mammals, birds, and reptiles
Subfamily III. Opisthorchiinæ

m_1. Yolk glands do not extend forward of acetabulum; uterus confined between intestinal cœca
Opisthorchis R. Bl. (Fig. 30) (44)

m_2. Yolk glands partly or wholly in front of acetabulum; uterus usually overlapping intestinal cœca.

n_1. Yolk glands entirely in front of acetabulum; uterus extends back of ovary to testes
Holometra Lss. (Fig. 31) (44)

n_2. Yolk glands partly behind acetabulum
Metorchis Lss. (Fig. 32) (44)

l_2. Stem of excretory vesicle usually entirely posterior to testes: cirrus sac present.

m_1. Testes lobate; prepharynx present
Subfamily II. Omphalometrinæ

n_1. Œsophagus absent; intestinal cœca do not extend into extremity of body; yolk glands meet in median line: in Ciconia
Omphalometra Lss. (Fig. 33) (44)

n_2. Œsophagus present.

o_1. Acetabulum pedunculate; ovary lobate; uterus extends in zigzags to genital pore; yolk glands meet in median line
Podocotyle Stoss. (51)

o_2. Ovary spherical; acetabulum sessile; uterus massed between them; yolk glands laterad of intestinal cœca
Cathæmasia Lss. (Fig. 34) (44)

m_2. Testes not lobate.

n_1. Yolk glands extend in front of acetabulum.

o_1. Anterior end with projecting ridges or with six papillæ.

p_1. Body subcylindrical; anterior end with four projecting, radial ridges: in turtles
Calycodes Lss. (Fig. 35) (49)

p_2. Anterior end with six papillæ, two being ventral and four dorsal: in fish
Crepidastomum Brn. (8)

o_2. Anterior end without ridges or papillæ; body broad and flat.

p_1. Yolk glands very extensive, overlapping intestinal cœca; ovary near testes and not near acetabulum: in fish
Halicometra Odh. (Fig. 104) (70)

p_2. Yolk glands not overlapping intestinal cœca: in amphibians
Opisthioglyphe Lss. (Fig. 47) (44)

n_2. Yolk glands do not extend in front of acetabulum
Subfamily VI. Psilostominæ

o_1. A pair of earlike papillæ present near mouth; body elongate.

p_1. Acetabulum small; testes ovoid: in turtles
Rhytidodes Lss. (Fig. 36) (49)

p_2. Acetabulum very large; testes reniform: in *Spilotes pullatus*, a Brazilian snake
Cotylotretus Odh. (Fig. 130) (71)

o_2. Anterior papillæ absent.

p_1. Anterior portion of body covered with large spines and often inflated; remainder of body with small spines: in fish
Deropristis Odh. (Fig. 105) (70)

p_2. No large anterior spines.

q_1. Œsophagus long; uterus short; receptaculum seminis and testes large: in fish
Allocreadium Lss. (Fig. 37) (44, 45)

q_2. Œsophagus very short or wanting; receptaculum seminis absent or small.

r_1. Yolk glands extend back of testes.

s_1. Large suckerlike genital papilla present in front of acetabulum; uterus extends to end of body
Ptychogonimus Lühe (Fig. 38) (51)

s_2. No genital papilla present; uterus short, in front of testes; prepharynx present; in birds and fish
Psilostomum Lss. (Fig. 39) (44)

r_2. Yolk glands do not extend back of testes; ovary far from acetabulum, the space between filled by the uterus; body elongate: in fish
Azygia Lss. (Fig. 40) (44)

j_2. Testes either two in number, in same transverse plane in hinder end of body, or many in number.

k_1. Testes numerous, in median field of body; no pharynx present; ovary just back of acetabulum: in ducks
Orchipedum Brn. (9)

k_2. Testes two in number, in same transverse plane
Subfamily IX. Cotylogoniminæ

l_1. Genital pore in acetabulum; yolk glands very voluminous: in birds . . . Cryptocotyle Lühe (Fig. 41) (50. 10)

l_2. Genital pore on a muscular suckerlike papilla at posterio-lateral side of acetabulum; œsophagus long; yolk glands small: in mammals
Cotylogonimus Lühe (Fig. 42) (50, 10)

h_2. Yolk glands compact, and lobate or tubular; worms oval or elliptical in shape; suckers large and often projecting; testes in extreme hinder end of body; cirrus sac long: in birds . . . . . Subfamily X. Philophthalminæ

i_1. Cirrus sac extends back of acetabulum; yolk glands tubular, laterad of intestinal cœca: under the eyelid of birds . . Philophthalmus Lss. (Fig. 43) (44)

i_2. Cirrus sac does not extend back of acetabulum; yolk glands lobate, not laterad of intestinal cœca: in cloaca of birds . . Pygorchis Lss. (Fig. 44) (44)

e_2. Uterus extends back of testes, usually to end of body.

f_1. Intestinal cœca long, extending more than half the length of body.

g_1. Ovary immediately behind or at side of acetabulum, or when not near it the intestinal cœca do not extend into hinder extremity of body.

h_1. Genital pore near the acetabulum or somewhere in front of it, but not at the extreme anterior or posterior end of body.

i_1. Mouth surrounded by papilla-like or long spinelike projections . . . . Subfamily XII. Bunoderinæ

j_1. Mouth surrounded by six contractile projections; no spines present; uterus consists of a descending and an ascending branch, without spinal windings: in fish
Bunodera Rail. (Fig. 45) (44, 86)

j_2. Mouth surrounded by long spinelike projections; uterus winds spirally: in Belone
Tergestia Stoss. (Fig. 46) (44)

i_2. No projections surrounding mouth.

j_1. Intestinal cœca usually do not reach the end of the body (longest in Opisthioglyphe); body usually spiny; excretory canal usually Y-shaped; cirrus sac present
Subfamily XI. Plagiorchiinæ

k_1. Uterus does not extend back of testes; œsophagus long; ovary at side of acetabulum: in amphibians
Opisthioglyphe Lss. (Fig. 47) (44)

k_2. Uterus extends back of testes.

l_1. Œsophagus wanting.

m_1. Yolk glands extend forward of the acetabulum.

n_1. Testes not in same transverse plane; cirrus sac extends back of acetabulum: in amphibians, reptiles, and birds Plagiorchis Lühe (Fig. 48) (50, 10)

n_2. Testes in same transverse plane.

o_1. Cirrus sac extends far back of acetabulum: in turtles Pachypsolus Lss. (Fig. 49) (49)

o_2. Cirrus sac extends to middle of acetabulum; body divided into two parts: in crocodiles Oistosomum Oldh. (71)

m_2. Yolk glands do not extend in front of acetabulum; body elongate, tapering to posterior end, which is truncated: in fish Glossidium Lss. (Fig. 50) (44)

l_2. Œsophagus present.

m_1. Body covered with minute spines or scales.

n_1. Testes not in same transverse plane.

o_1. One intestinal cœcum much longer than the other; testes elongate; a single row of spines around mouth: in fish Subfamily VII. Anisocœlinæ

p_1. Testes very small, in center of body; ovary lobate; uterus does not extend to end of intestinal cœca Anisocœlium Lühe (Fig. 23) (52)

p_2. Testes in hinder half of body; ovary spherical; uterus extends to end of body Anisogaster Lss. (Fig. 24) (48)

o_2. Intestinal cœca of equal length.

p_1. Oral sucker larger than acetabulum; yolk glands extend in front of latter; stem of excretory vesicle very long, winding between testes; receptaculum seminis minute; cirrus sac long: in aquatic vertebrates Astiotrema Lss. (Fig. 51) (44, 45)

p_2. Oral sucker smaller than acetabulum; yolk glands do not extend in front of latter; testes lobate; receptaculum seminis large; stem of excretory vesicle short: in reptiles Styphlodora Lss. (Fig. 52) (44, 77)

n_2. Testes in nearly or quite the same transverse plane and lobate; oral sucker smaller than acetabulum; yolk glands extend about to acetabulum; receptaculum seminis absent or minute; stem of excretory vesicle very long: in reptiles Renifer Pratt (Fig. 53) (77)

m_2. Body not spiny; cirrus sac very wide in front of acetabulum; yolk glands composed of a single row of follicles on each side: in turtles

Endiotrema Lss. (Fig. 54) (44, 45)

j_2. Intestinal cœca reach into extremity of body; testes usually in oblique plane or one behind the other.

k_1. Large suckerlike genital papilla present in front of acetabulum; suckers large; excretory crura join at anterior end

Ptychogonimus Lühe (Fig. 38) (51)

k_2. No genital papilla present . Subfamily XIV. Haplometrinæ

l_1. Genital pore just behind pharynx; cirrus sac very long and narrow.

m_1. Acetabulum larger than and near oral sucker; body elongate; testes and ovary in forward half of body; receptaculum seminis wanting or minute

Macrodera Lss. (44)

m_2. Acetabulum smaller than oral sucker and not near it; uterus very long and deeply colored; receptaculum seminis very large; Laurer's canal wanting; œsophagus wanting or short.

n_1. Uterus in long longitudinal folds; ovary beside acetabulum: in lungs of amphibians

Hæmatolœchus Lss. (Fig. 55) (44)

n_2. Uterus in transverse folds; ovary behind acetabulum, which is minute; testes very large: in frogs

Ostiolum Pratt (Fig. 56) (77)

l_2. Genital pore near acetabulum.

m_1. Genital pore just in front of acetabulum.

n_1. Œsophagus present.

o_1. Pharynx present.

p_1. Yolk glands extensive and dendritic; body elongate: in amphibians

Haplometra Lss. (Fig. 57) (44)

p_2. Yolk glands small, on each side of acetabulum; testes in same transverse plane just behind them; ovary to right of and just behind acetabulum; body broad: in fish

Callodistomum Odh. (70)

o_2. Pharynx absent; body broad; yolk glands very small lobate bodies just behind acetabulum

Phyllodistomum Brn. (Fig. 63) (8)

n_2. Œsophagus absent; body very broad; testes a large number of small round bodies

Anaporrhutum Ofén. (Fig. 64) (67)

m_2. Genital pore behind and to left of acetabulum; cirrus sac U-shaped: in snakes
Opisthogonimus Lühe (Fig. 58) (50, 10)

h_2. Genital pore at the extreme anterior or posterior end of the body.

i_1. Genital pore in front of or at side of oral sucker
Subfamily XX. Cephalogoniminæ

j_1. Testes one behind the other; cirrus sac very long.

k_1. Excretory vesicle large, with long stem and crura, both of which throw out side branches; genital pore in front of oral sucker
Cephalogonimus Poir. (Fig. 59) (44)

k_2. Excretory vesicle with long stem, short crura, and without side branches; genital pore at right of oral sucker: in fish Emoleptalea Lss. (Fig. 60) (44, 45)

j_2. Testes in nearly same transverse plane and lobate; genital pore at left of oral sucker; ovary lobate: in birds
Prosthogonimus Lühe (Fig. 61) (50, 10)

i_2. Genital pore at extreme hinder end of body; testes and ovary in median line, the latter just behind acetabulum, the former just in front of cirrus sac with the uterus between: in bats
Urotrema Brn. (9)

g_2. Ovary not immediately behind or at side of acetabulum; intestinal cœca extend to end of body.

h_1. Genital pore in front of acetabulum and median; yolk glands small, being spherical, lobate, or dendritic bodies near the middle of the body.

i_1. Yolk glands spherical; excretory crura join near the pharynx: acetabulum large . . . . Liopyge Lss. (Fig. 88) (44)

i_2. Yolk glands lobate or dendritic.

j_1. Pharynx absent; yolk glands small and lobate: in urinary bladder of cold-blooded vertebrates
Subfamily XVI. Gorgoderinæ

k_1. Body elongate; either one pair of testes or four testes on one side and five on the other
Gorgodera Lss. (Fig. 62) (44)

k_2. Body broad and leaflike; one pair of testes
Phyllodistomum Brn. (Fig. 63) (8)

j_2. Pharynx present; body broad and leaflike: testes either numerous or two in number Subfamily XV. Anaporrhutinæ

k_1. Testes made up of a large number of small bodies: yolk glands small and dendritic; uterus not laterad of intestinal cœca Anaporrhutum Ofen. (Fig. 64) (67)

k_2. Testes two large, lobate bodies; yolk glands lobate: uterus extends laterad of intestinal cœca: in turtles
Plesiorchorus Lss. (Fig. 65) (46)

h_2. Genital pore on edge of body.

i_1. Genital pore on right edge of body opposite pharynx; suckers very large; testes in same transverse plane in front of acetabulum: in birds
Stromylotrema Lss. (Fig. 66) (44, 45)

i_2. Genital pore on left edge of body opposite acetabulum; but one testis present: in fish
Asymphylodora Lss. (Fig. 67) (44)

f_2. Intestinal cœca very short, extending but little, if any, beyond the acetabulum, and often not to it; excretory vesicle usually wide, long, and V- or Y-shaped; testes usually in same transverse plane.

g_1. Intestinal cœca reach about to acetabulum or a little beyond, and are usually longer than the œsophagus; yolk glands small . . . . . . Subfamily XIX. Pleurogenetinæ

h_1. Genital pore at left side of body near forward end; cirrus sac large.

i_1. Testes small, lobate, just behind yolk glands and ovary, all being behind acetabulum: in fish
Lepidophyllum Odh. (Fig. 106) (70)

i_2. Yolk glands and ovary in front of testes: in amphibians and reptiles.

j_1. Testes one on each side of acetabulum; œsophagus long; body elliptical
Pleurogenes Lss. (Fig. 68) (43, 44)

j_2. Testes far in front of acetabulum and ovary; body oval or round; œsophagus short
Prosotocus Lss. (Fig. 69) (44)

h_2. Genital pore in or very near acetabulum.

i_1. Genital pore in anterior border of acetabulum; excretory vesicle Y-shaped and very long
Gymnophallus Odhner (Fig. 70) (69)

i_2. Genital pore not in acetabulum.

j_1. Genital pore at left side of acetabulum: yolk glands behind testes
Levinsenella S. et H. (Fig. 71) (44, 15)

j_2. Genital pore in front of acetabulum; yolk glands in front of testes: in Corone
Ochetosoma Brn. (9)

g_2. Intestinal cœca very short, usually falling short of acetabulum; ovary usually near acetabulum; yolk glands small; testes usually in same transverse plane
Subfamily XVII. Brachycœliinæ

h_1. Body elongate and spiny.

i_1. Acetabulum small, about size of oral sucker; cirrus sac large and extending back of acetabulum; yolk glands dendritic, extending in front of acetabulum: in turtles
Cymatocarpus Lss. (Fig. 72) (44)

i_2. Acetabulum very large; cirrus sac small, in front of acetabulum; yolk glands lobate, behind acetabulum: in amphibians and reptiles
Brachycœlium Duj. (Fig. 73) (44)

h_2. Body short, oval, usually spiny.

i_1. Testes behind and ovary to right of acetabulum.

j_1. Genital pore median, in front of acetabulum; yolk glands, one on each side of acetabulum: in bats
Pycnoporus Lss. (Fig. 74) (44)

j_2. Genital pore at left side of acetabulum
Subfamily XVII. Microphallinæ

k_1. Yolk glands lobate, in hinder part of body; vesicula seminalis large, in front of acetabulum; no spines: in fresh-water fish
Microphallus Ward (Fig. 75) (92, 94)

k_2. Intestinal cœca reach a little beyond acetabulum; spines present
Levinsenella S. et H. (Fig. 71) (44. 15)

i_2. Testes in front of or on each side of acetabulum.

j_1. Genital pore median, between oral sucker and acetabulum; testes one on each side of and ovary to left of acetabulum.

k_1. Genital pore near acetabulum; œsophagus long; yolk glands behind acetabulum; no cirrus sac: in bats and chameleons
Lecithodendrum Lss. (Fig. 76) (44)

k_2. Genital pore near pharynx; œsophagus short: yolk glands far in front of acetabulum; long cirrus sac present: in birds and mammals
Phaneropsolus Lss. (Fig. 77) (44)

j_2. Genital pore at left side of body; acetabulum in hinder part of body; all the genital glands in front of them; œsophagus short: in frogs
Brandesia Stoss. (Fig. 78) (44)

d_2. Ovary behind testes.

e_1. Testes in front of acetabulum, in same transverse plane.

f_1. Ovary behind acetabulum; suckers large; genital pore near pharynx; no œsophagus present: in cloaca of birds
Eumegacetes Lss. (Fig. 79) (44, 45)

f_2. Ovary in front of acetabulum; suckers not large.

g_1. Genital pore at extreme hinder end: in birds
Urorygma Brn. (9)

g_2. Genital pore in front of acetabulum; intestinal cœca not reaching acetabulum.

h_1. Genital pore median.

i_1. Cirrus sac long; yolk glands in front of acetabulum: in birds and mammals
Phaneropsolus Lss. (Fig. 77) (44)

i_2. No cirrus sac; yolk glands behind acetabulum: in bats and chameleons
Lecithodendrium Lss. (Fig. 76) (44)

h_2. Genital pore on left edge of body; cirrus sac long; genital glands all in front of acetabulum: in amphibians and reptiles
Prosotocus Lss. (Fig. 69) (44)

e_2. Testes behind acetabulum.

f_1. Yolk glands dendritic and along the sides of the body.

g_1. Testes one behind the other; body elongate; intestinal cœca extending to end of body.

h_1. Yolk glands consist of a series of branched tubular follicles on each side.

i_1. Œsophagus very long; each intestinal cœcum sends a long projection forward, giving the digestive tract the form of an H; acetabulum often pedunculate: in fish
Accacœlium Mont. (Fig. 80) (44, 59)

i_2. Acetabulum not pedunculate; digestive tract not in form of an H; acetabulum in middle of body, the anterior half of which is flat, the posterior half cylindrical
Eurycœlum Brock. (55)

h_2. Yolk glands not of tubular follicles, but of spheroidal masses; œsophagus short; suckers near together: usually in the liver Subfamily XXI. Dicrocœliinæ

i_1. But one yolk gland, the left one, present: in liver of birds . . . Athesmia Lss. (Fig. 81) (44)

i_2. A pair of yolk glands present.

j_1. Body flat and leaf-like
Dicrocœlium Duj. (Fig. 82) (44, 86)

j_2. Body cylindrical
Lyperosomum Lss. (Fig. 83) (44)

g_2. Testes in same transverse plane or nearly so; intestinal cœca extend to end of body; excretory canal Y-shaped; cirrus sac wanting: in bats and chameleons
Anchitrema Lss. (44)

f_2. Yolk glands compact, or if dendritic, of small extent and not along the sides of the body.

g_1. Genital pore in front of acetabulum.

h_1. Yolk glands in hinder end of body.

i_1. Distal ends of intestinal cœca joined; distal ends of excretory crura also joined: in marine fish
Subfamily XXIII. Syncœliinæ

j_1. Yolk glands compact, spherical; testes in same transverse plane: in the stomach
Progonus Lss. (Fig. 84) (44)

j_2. Yolk glands dendritic: on gills of sharks.

k_1. Intestinal cœca have side branches; testes and ovary dentritic; acetabulum pedunculate; anterior portion of body cylindrical, posterior flat and folded
Otiotrema Setti (Fig. 85) (44)

k_2. Intestinal cœca without side branches; ovary deeply lobate; testes in two longitudinal rows of isolated lobes
Syncœlium Lss. (Fig. 86) (44)

i_2. Distal ends of intestinal cœca not joined; testes usually in same transverse plane in hinder end of body; uterus in transverse folds, passing to anterior end of body: in amphibians
Halipegus Lss. (Fig. 87) (44)

h_2. Yolk glands near or towards the middle of the body (except Derogenes); excretory crura usually joining over the pharynx; small cylindrical or elliptical forms, in most of which the hinder end of the body is telescopic: in marine fish
Subfamily XXII. Hemiurinæ

i_1. Hinder end of body not telescopic (no appendix); genital pore near branching of intestine.

j_1. Testes behind ovary and diagonally behind each other; yolk glands in front of ovary; all genital glands spherical
Liopyge Lss. (Fig. 88) (44)

j_2. Testes in front of ovary, in nearly same transverse plane: yolk glands lobate and behind ovary
Derogenes Lühe (Fig. 89) (52, 55)

i_2. Hinder end of body telescopic (with appendix).

j_1. Body elongate, finely ringed.

k_1. Yolk glands spherical, behind ovary; appendix either long, medium, or short; receptaculum seminis large
Hemiurus R. (Fig. 90) (44, 55, 57, 76)

k_2. Yolk glands composed of three or four long, involved tubes on each side; appendix long
Lecithocladium Lühe (Fig. 91) (55)

j_2. Body fusiform or ovate; not ringed.

k_1. Yolk glands spherical, near acetabulum; excretory crura do not join anteriorly; testes in same transverse plane; appendix very short
Pronopyge Lss. (Fig. 92) (44)

k_2. Yolk glands deeply lobate or tubular, behind testes.

l_1. Yolk glands apparently joined to form a single star-shaped body
Lecithaster Lühe (Fig. 93) (55)

l_2. Yolk glands distinctly separate from each other, and each composed of three or four tubular lobes
Lecithochirium Lühe (Fig. 94) (55)

g_2. Genital pore on left edge of body nearly opposite acetabulum; but one yolk gland present, a small ovoid structure in center of the body; testes in same transverse plane: in fish . . . . Subfamily XXVI. Zoögoninæ

h_1. Testes just back of acetabulum; yolk gland just in front of ovary . . Zoögonus Lss. (Fig. 95) (47)

h_2. Testes one on each side of acetabulum; yolk gland just behind ovary
Zoögonoides Odh. (Fig. 96) (70)

d_3. Ovary between the testes, which are often one behind the other.

e_1. Genital pore in front of acetabulum; suckers large; œsophagus and intestinal cœca long; testes and cirrus sac large; yolk glands extensive, along entire sides of body: in fish
Spærostoma R. (Fig. 97) (44, 86)

e_2. Genital pore behind acetabulum.

f_1. Genital pore at hinder extremity of body; œsophagus absent: yolk glands voluminous: in birds and bats
Subfamily XXV. Urogoniminæ

g_1. Suckers very large; testes obliquely behind each other; body broad . . . Urogonimus Mont. (Fig. 98) (44)

g_2. Suckers not large; testes directly behind one another; body elongate . . Urotocus Lss. (Fig. 99) (44)

f_2. Genital pore not at hinder extremity of body but usually near testes.

g_1. Genital pore between testes, which are very large and broken up into a large number of distinct parts; no pharynx, a long œsophagus, and long intestinal cœca present: in sea turtles
Hapalotrema Lss. (Fig. 100) (44)

g_2. Testes not broken into small parts.

h_1. Mouth surrounded by circular ridge; intestine usually with short lateral projections
Subfamily XXVII. Clinostominæ

i_1. Genital pore just in front of testes; pharynx absent: in mouth of birds
Clinostomum Leidy (Fig. 101) (21, 6)

i_2. Genital pore a short distance in front of posterior end; pharynx present: in crocodiles
Nephrocephalus Odh. (71)

h_2. Mouth not surrounded by ridge
Subfamily XXIV. Harmostominæ

i_1. Genital pore in front of anterior testis.

j_1. Body linguiform; mouth a slit; ovary and testes in extreme hinder end: in mammals
Harmostomum Brn. (Fig. 102) (10)

j_2. Body very elongate and cylindrical; genital glands not in extreme hinder end: in birds . . . Scaphistomum Brn. (9)

i_2. Genital pore between the testes.

j_1. Body very elongate, tapelike; acetabulum very small; oral sucker large; genital pore near forward end of hinder testis: testes far apart: in Talpa
Ityogonimus Lühe (Fig. 103) (50, 10)

j_2. Body elongate, linguiform; genital pore just behind anterior testis; mouth circular: in Mycotheria from Brazil
Glaphyrostomum Brn. (9)

c_2. Worms diœcious . . . . Family III. Schistosomidæ

d_1. Hinder portion of body expanded in both sexes: female shorter than male: in the blood and liver of birds . Bilharziella Lss. (44)

d_2. Body cylindrical in both sexes or expanded in female.

e_1. Female longer than male and filiform, and enclosed in the gynæcophoric canal of the latter: in the blood of mammals
Schistosoma Wein. (Fig. 107) (44)

e_2. Male and anterior portion of female filiform; posterior portion of female swollen and reniform: in the mouth and gill clefts of fish, living in cysts, a male and a female being in a cyst . Kœllikeria Cob. (Fig. 108) (86)

a_2. Two suckers present, the oral sucker and the ventral acetabulum, together with a large, variously constructed ventral projection, or disk, of use in attachment . . . . . . Family IV. Holostomidæ

b_1. Body circular, not made up of two portions; acetabulum usually covered by a large disklike structure which possesses a large cavity extending itself into a longitudinal groove: in intestine of birds . . . . Cyathocotyle Mühl. (Fig. 109) (60)

b_2. Body elongate and made up of two distinct portions, the anterior portion being usually flattened and containing the acetabulum and the special organ of attachment.

c_1. Lateral edges of anterior portion not bent ventrally; special organ of attachment an elongated depression lined with papillæ . . . . Subfamily II. Diplostominæ

d_1. A row of mid-dorsal suckers on hinder part of body: in intestine of the alligator

Polycotyle Will.-S. (Fig. 110) (95)

d_2. No dorsal suckers: in intestine of reptiles and birds

Diplostomum v. Nord. (Fig. 111) (3)

c_2. Lateral edges of anterior portion bent ventrally.

d_1. Anterior portion trough-shaped; special organ of attachment an elongated elevation, which may project over the acetabulum.

e_1. In birds and land mammals

Hemistomum Dies. (Fig. 112) (3)

e_2. In Delphinus . . . . Braunina Heider (12)

d_2. Lateral edges of anterior portion meet and fuse mid-ventrally, making this part of the body cup-shaped; special organ of attachment a conical projection: usually in birds . . . . . Holostomum Nit. (Fig. 113) (3)

a_3. But one sucker present and no other organ of attachment.

b_1. Mouth in the middle of the ventral body surface; sucker at anterior end; intestine not bifurcate; genital and excretory pores at posterior end: in the intestine of fish

Gasterostomum v. Sieb. (Fig. 114) (33)

b_2. Mouth at anterior end, sucker oral.

c_1. Worms found in pairs in cysts on the gills, outer surface, or in the mouth of fish; intestine often rudimentary or wanting

Family VI. Didymozoönidæ

d_1. Anterior portion of body slender and cylindrical, posterior portion thick and cylindrical, or reniform

Didymozoön Tasch. (Fig. 115) (3)

d_2. Body very elongate (up to a meter in length) and filiform; intestine wanting but mouth present . . Nematobothrium v. Ben. (3)

c_2. Worms not found in pairs enclosed in cysts Family VII. Monostomidæ

d_1. Testes directly behind one another in middle of body; ovary behind them; body usually elongate, anterior end not set off; genital pore near anterior end; cirrus sac wanting; uterus not voluminous; intestinal cœca do not extend to end of body: in intestine of reptiles . . . . Subfamily I. Microscaphidiinæ

e_1. Uterus confined between intestinal cœca
Microscaphidium Lss. (Fig. 116) (44, 45)

e_2. Uterus overlaps intestinal cœca
Deuterobaris Lss. (Fig. 117) (44, 45)

d_2. Testes either in same transverse plane or obliquely behind one another; ovary usually in front of testes or between them.

e_1. Genital pore at hinder end of body, which is broad: pharynx wanting: in Halicore Opisthotrema Leuck. (Fig. 118) (3)

e_2. Genital pore in anterior half of body.

f_1. Intestinal cœca join at their hinder ends; testes obliquely behind one another: in water birds
Cyclocœlum Brds. (Fig. 119) (44)

f_2. Intestinal cœca not thus joined.

g_1. Anterior end more or less triangular, being set off by a circular muscular ridge from rest of body; testes and ovary often lobate in hinder end of body: in marine turtles . . . . . Subfamily II. Pronocephalinæ

h_1. Anterior ridge with a deep indentation on the ventral side.

i_1. Ovary in front of testes, of which two are present.

j_1. Intestinal cœca without side projections and with their posterior ends laterad of the testes; latter not in same transverse plane
Pronocephalus Lss. (Fig. 120) (44)

j_2. Intestinal cœca with side projections and with their posterior ends mediad of testes, which are in same transverse plane.

k_1. Ventral surface with four longitudinal rows of groups of glands
Adenogaster Lss. (49)

k_2. No ventral glands.

l_1. Anterior circular ridge very high; vesicula seminalis very long and winding skeinlike outside the cirrus sac
Glyphicephalus Lss. (49)

l_2. Anterior ridge not noticeably high; vesicula seminalis not skeinlike Pleurogonius Lss. (Fig. 121) (49)

i_2. Ovary behind testes, of which about fifteen are present, arranged in two longitudinal parallel rows Charaxicephalus Lss. (49)

h_2. Anterior circular ridge without ventral indentation; intestinal cœca with numerous side projections; testes and ovary deeply lobate in hinder end of body.

i_1. Hinder end of body truncated or concave; cirrus sac long and with vesicular seminalis extending the greater part of the length of the body . Cricocephalus Lss. (Fig. 122) (44)

i_2. Hinder end of body rounded; cirrus sac in transverse plane Pyelosomum Lss. (Fig. 123) (44)

g_2. Anterior end not set off from rest of body.

h_1. Longitudinal ridges or rows of glands on ventral surface; testes in same transverse plane in hinder part of body.

i_1. Three rows of glands on ventral surface; intestinal cœca long and without projections; ovary between testes: in birds Notocotylus Dies. (Fig. 124) (44)

i_2. About fifteen longitudinal ridges on ventral surface; cirrus sac very large: in intestine of cetaceans Ogmogaster Jäg. (Fig. 125) (3)

h_2. Ventral surface without ridges or rows of glands.

i_1. Yolk glands laterad of intestinal cœca in hinder portion of body; testes in oblique plane.

j_1. Ovary between testes; intestinal cœca very narrow; uterus extends to end of body: in birds Stictodora Lss. (Fig. 126) (44)

j_2. Ovary in front of testes; intestinal cœca broad; uterus in front of ovary: in fish Galactosomum Lss. (Fig. 127) (44)

i_2. Yolk glands on both sides of intestinal cœca in middle and hinder part of body.

j_1. But one testis present; ovary in front of it: in Bagrus Haplorchis Lss. (Fig. 128) (44)

j_2. Testes in same transverse plane: ovary behind them; intestinal cœca enclose both; body circular or oval: in Box Mesometra Lühe (Fig. 129) (54)

(*To be continued*)

NOTES AND LITERATURE.

ZOÖLOGY.

Beddard's "Mammalia."[1] — Through the publication of this excellent manual of the class Mammalia Mr. Beddard has placed the general student under lasting obligations. The subject could hardly be more judiciously treated in the limited space of a single convenient volume of six hundred pages. In scope and general character it occupies nearly the same field as Flower and Lydekker's *An Introduction to the Study of Mammals, Living and Extinct*, published in 1891, and now necessarily in some respects a little out of date. The two works are, however, naturally constructed on practically the same plan.

The "Scheme of Classification" (pp. ix–xii) recognizes only two subclasses, the Prototheria (Allotheria, Marsh; Multituberculata, Cope), including the echidnas and the duckbill, and the Eutheria, comprising all the other members of the class. These latter are divided among the following thirteen orders:

Marsupialia,
Edentata,
Ganodonta,
Ungulata,
Sirenia,
Cetacea,
Carnivora,
Creodonta,
Rodentia,
Tillodontia,
Insectivora,
Chiroptera,
Primates.

The orders are further subdivided into 28 suborders (of which six are extinct) and 109 families. The number of species is stated to be 3000, but this is obviously far too low an estimate, even for the existing species. Trouessart, in his *Catalogus Mammalium* (1897, 1898), listed upward of 7300, and hundreds have since been added. Doubtless 8000 to 10,000 species would not be too high an estimate for both fossil and recent.

[1] Beddard, F. E. *Mammalia*. The Cambridge Natural History, vol. x. London, Macmillan, 1902. 8vo, xii + 605 pp., 285 figs.

In the brief introduction (pp. 1–4) the class Mammalia is very satisfactorily defined; and in reference to their position as the "highest of the Vertebrates," the term "highest," in comparison with "specialization," is considered, and its use in such a connection is amply defended, since "specialization" does not necessarily imply the perfection and complexity of structure that is involved in the term "highest." "Most specialized" and "highest," and "least specialized" and "lowest" are therefore not the equivalent alternatives some writers have considered them to be, and in preferring the former to the latter as more definite and exact expressions they have not thereby secured greater accuracy of statement.

An exposition of the structure of mammals occupies pages 5–78, and deals concisely with their external form, skeleton, skull, teeth, the organs of digestion, respiration, reproduction, the brain, etc., with numerous well-chosen illustrations. The present distribution of the class and the subject of zoölogical regions is treated less satisfactorily (pp. 78–89): because the tiger "is as much at home in a tropical jungle as on the icy plains of northern Asia" is no proof that "the world cannot be mapped out into areas bounded by parallels of temperature"; because there are a few wide-ranging types it does not follow that temperature does not constitute one of the most powerful controlling influences in the distribution of life over the globe. The primary regions and their subdivisions here adopted are, however, those now most generally accepted.

Chapter III (pp. 90–95) considers "The Possible Forerunners of the Mammalia," and Chapter IV (pp. 96–104) is entitled "The Dawn of Mammalian Life"; both subjects are carefully and conservatively treated. The rest of the volume takes up the orders of mammals in their systematic sequence, from monotremes to primates. Respecting this part of the work the author says: "I have given, I hope, adequate treatment from the standpoint of a necessarily limited treatise to the majority of the more important genera of mammals both living and extinct." Such groups as the Edentata and Marsupialia are given relatively, and very appropriately, much more space than is accorded to many of the other orders. On the other hand, the Rodentia and Chiroptera, with their multitude of forms, are treated so briefly that one almost regrets that the plan of the work did not permit of an additional hundred pages or so, in order to more fully notice these and a few other groups now very briefly noticed or quite omitted. But the author has given us so much that is good in this excellent manual that it is rather ungracious to make

such omissions, doubtless seemingly necessary from the publishers' standpoint, a matter of criticism.

Notwithstanding the general excellence of Mr. Beddard's *Mammalia*, there are a few slips and misstatements that should hardly pass without notice. While generally free from typographical errors, the reference on p. 415 to "Wortman and Malkens" might puzzle readers unprepared to recognize that "Malkens" is a misprint for Matthew. As a general criticism, it may be stated that the author is averse to the adoption of most of the recent changes in nomenclature, due to the enforcement of the foundation principle of nomenclature, the rule of priority. A few of them — and among them some of the most unwelcome — have been adopted, but in most instances the author is content to say, as in the notorious case of Trichechus for the walruses: "This family contains but one genus, *Trichechus*, . . . or *Odobænus*, as the more correct term seems to be." And so on in many other instances, temporary convenience, at the cost of a vitiated nomenclature, being preferred to the slight inconvenience of introducing to the general public, and particularly to the rising generation of students, names recently established as the correct names, and which will therefore, sooner or later, become the familiar names in the literature of the subject. The conservatism of habit is thus allowed to retard progress in the attainment of a correct and stable nomenclature. Incidentally it may be added that the author recognizes only one species of walrus instead of two: which is only to be explained on the ground of inertia or conservatism, and lack of actual investigation of the point in question; for although Mr. Beddard is almost ultra-conservative in the matter of species and genera, it is hardly possible to believe that he could say, "There is but one species of walrus, though it has been attempted to show that the Pacific and Eastern forms are different," if he had actually compared the skulls of the two forms.

In his comment on the elephants he notes that (p. 221) the African elephant "has been sometimes referred to a distinct genus or subgenus, Loxodon," and later (p. 223) speaks of the Indian elephant as "*Euelephas indicus*, if the genus Loxodon is to be accepted": whereas in reality the Indian elephant would in such case retain the name *Elephas indicus*, *Euelephas* being a synonym of *Elephas*. Judging from his treatment of the rhinoceroses (to pass over many other similar cases), the author's conception of genera is open to revision, since such groups (as well as the higher groups) are supposed to indicate degree of differentiation regardless of whether they consist of a

single species or many; and not that diverse types are to be thrown together, if they happen to have some striking features in common and are each represented by single species.

The enumeration of Reithrodontomys as a characteristic South American genus (p. 480) is probably an inadvertence, as is perhaps the statement that Capromys "is found only in the islands of Cuba and Jamaica," whereas there is a species in the Bahamas, another on Swan Island, coast of Honduras, and still another in Venezuela. It is, however, surprising to find currency again given, especially in a work of high scientific standing, to the long since exploded myth of the "happy-family" relations of the prairie dog, owl, and rattlesnake. It is also rather surprising to find the statement (p. 518) that the common mole of the eastern United States (*Scalops aquaticus*) is "a creature of largely aquatic habits," — a wholly false inference, derived apparently from the animal's unfortunate specific name. It is also not quite true that the arctic fox (*Canis lagopus*) "is known by its bluish summer coat and pure white winter dress as 'blue fox' and 'white fox' respectively." This has been so often stated in books of natural history that Mr. Beddard cannot be blamed for repeating it; but the truth is that the blue and white phases are not altogether seasonal conditions, since at some localities, as the Aleutian and Pribilof Islands, only blue foxes are found. Indeed the blue foxes of these islands are regarded by the latest authorities on the group as specifically distinct from the white fox.

The foregoing criticisms relate for the most part to minor matters, which do not seriously detract from the value of the work. As would be expected, Mr. Beddard's treatment of his subject is thorough, and fairly represents the latest generally accepted views and results in systematic mammalogy, a field in which he has long been an energetic worker and a recognized authority. The publishers have done well their part in placing before the public a needed work of great merit in pleasing form. The paper and typography are all that could be desired, and the illustrations, abundant and well-selected (those of structural characters are mainly after Flower, Wiederscheim, De Blainville, Osborn, and others), are printed with admirable clearness. Mr. Dixon's numerous full-length drawings are of unequal merit, but most of them are both satisfactorily artistic and effective, while some are admirable.

J. A. A.

QUARTERLY RECORD OF GIFTS, APPOINTMENTS, AND DEATHS.

EDUCATIONAL GIFTS.

Ohio State University, $5000, from Prof. S. W. Robinson, Vassar College; 10,000, by the will of Adolph Sutro.

APPOINTMENTS.

Jean Brèthes, custodian of insects in the museum at Buenos Aires. — Dr. Oskar Ebert, custodian of the collections of the Prussian Geological Survey. — T. W. Galloway, professor of biology in Milliken University, Decatur, Ill. — Professor Griffon, professor of botany in the National School for Agriculture at Grignon, France. — Dr. Maurice Jaquet, conservator of the oceanological museum at Monaco. — Dr. Fridolin Kasser, professor of botany in the Vienna Agricultural School. — Dr. Adolf Klautsch, district geologist of the Prussian Geological Survey. — Dr. Benno Kühn, geologist of the Prussian Geological Survey. — Dr. R. S. Lillie, instructor in physiology and histology in the University of Nebraska. — Dr. Lorenz v. Liburnau, docent for zoölogy in the Vienna Agricultural School. — Dr. Raymond Pearl, instructor in zoölogy in the University of Michigan. — Dr. Henry F. Perkins, assistant professor of biology in the University of Vermont. — A. R. Ruggles, assistant to the state entomologist of Minnesota. — Dr. Sommerfeldt, docent for mineralogy in the university at Tübingen. — Dr. Paul Sorauer, docent for plant pathology in the university at Berlin. — Dr. F. L. Stevens, professor of biology in the Agricultural College at Raleigh, N.C. — Dr. Robert H. Wolcott, assistant professor of zoölogy in the University of Nebraska. — Dr. Wilhelm Wolff, district geologist of the Prussian Geological Survey. — Dr. Oskar Zoth, professor of physiology in the university at Innsbruck. — Prof. R. Albrecht Zimmermann, botanist of the biological station Amani, in German East Africa.

DEATHS.

Alfred Blavy, entomologist, in Montpellier, France. — Oliver Collett, student of the Mollusks of Ceylon, at Colombo, June 13, aged 35. — John Edward Fletcher, British entomologist, at St. Johns, February 26, aged 66.

— Petrus Heude, missionary and naturalist, near Shanghai, China, January 3, aged 66. — George Samuel Jenman, government botanist, in Georgetown, British Guiana, February 28, aged 56. — Prof. Dr. A. Ludwig G. Leimbach, editor of the *Deutsche botanische Monatsschrift*, in June, aged 53. — William Neale Lockington, a student of Crustacea and fishes, and at one time a considerable contributor to this journal, at Worthing, Sussex, England, August 3, aged about 60. — John William May, entomologist, in London, June 17, aged 78. — Antonio Mori, professor of botany, at Modena, April 6. — Felix Nawrocki, emeritus professor of physiology, in Warsaw, June 3, aged 64. — David Pacher, author of a flora of Carnathia, aged 86. — Dr. P. Plósz, professor of physiology, at Budapest, aged 57. — Dr. Bernard Schmidt, docent for botany in Tübingen, May 28, aged 35. — Dr. Michael Tichomiroff, professor of anatomy in the university at Kieff, May 30, aged 54. — Charles M. Wakefield, student of the insects of New Zealand, May 11, aged 64.

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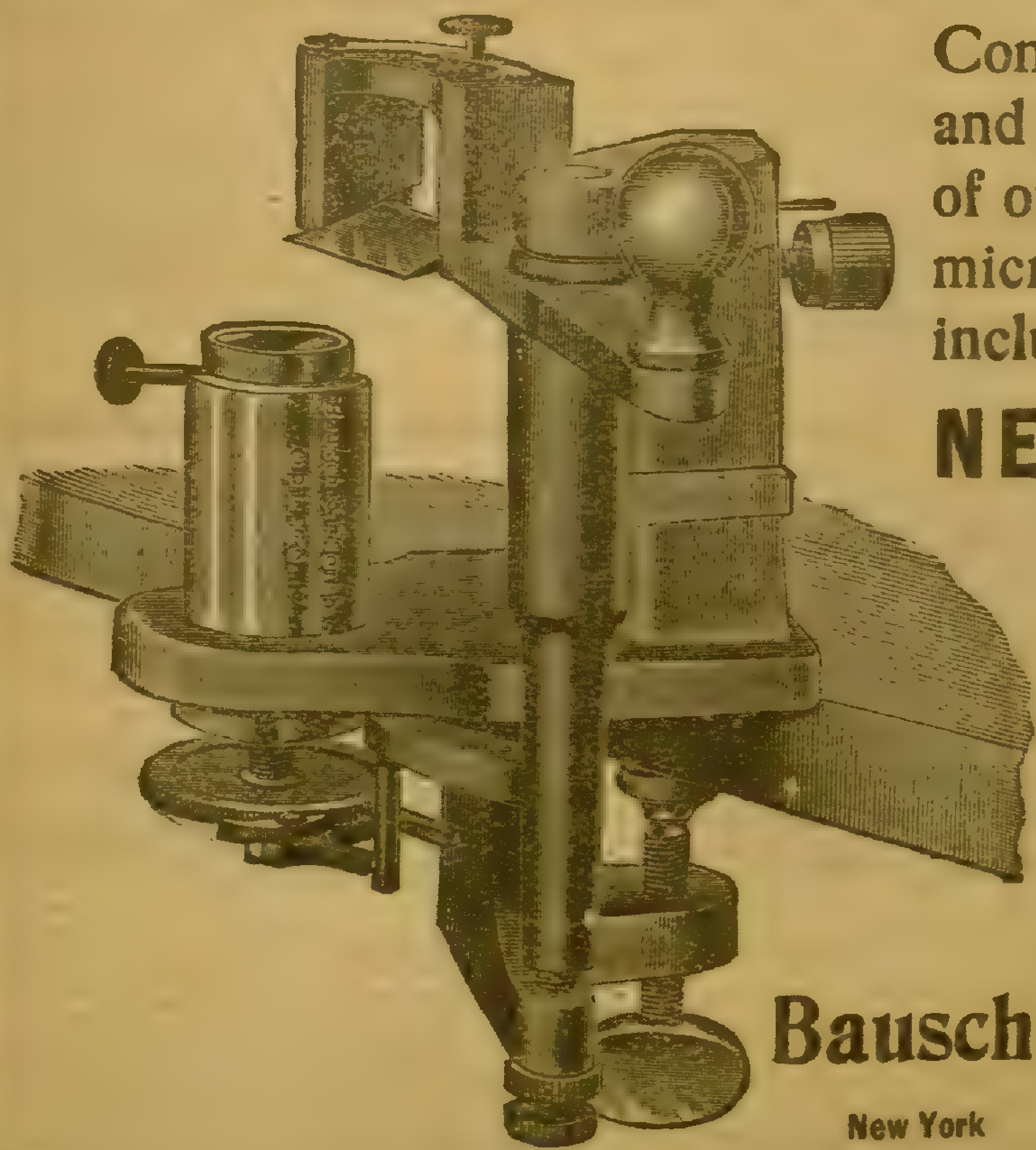

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THE AMERICAN NATURALIST

A MONTHLY JOURNAL
DEVOTED TO THE NATURAL SCIENCES
IN THEIR WIDEST SENSE

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THE

AMERICAN NATURALIST

Vol. XXXVI. *December, 1902.* No. 432.

STUDIES OF GASTROPODA.

AMADEUS W. GRABAU.[1]

Marine gastropods appear to have reached their acme of development in the present geologic period. What the Jurassic and early Cretaceous time was to the cephalopods, the Tertiary and present periods are to the gastropods. This is indicated not only by the great number of species, but also by the fact that so many series have branched out into bizarre types, in which excessive development of spines and tubercles suggests that the limit of variation is approached.[2] Phylogerontic types are furthermore to be found in the majority of series, while some groups, such as Strombus, Cypræa, etc., are represented only by phylogerontic forms in the modern seas.

[1] The author has for the past five years been engaged in the study of the phylogeny of gastropods, particularly the Fusidæ and some related types. A monograph on Fusus and some of its allies is ready for the press, while another, dealing especially with Fulgur and its allies, is in preparation. The present paper is intended as a contribution to the principles of study of the molluscan shell as applied to Gastropoda, principles first worked out for the Cephalopoda by the late Prof. Alpheus Hyatt and some of his contemporaries, and for the Pelecypoda by Prof. R. T. Jackson.

[2] See Beecher, Origin and Development of Spines, *Amer. Journ. of Sci.*, Ser. 4, vol. vi (1898), pp. 329–359; also *Studies in Evolution*, pp. 93 *et seq.*, Scribner, 1901.

The Protoconch of Gastropods. — The apical whorl of a gastropod shell has come to be generally known as the protoconch, though this term had been preoccupied for the corresponding apex of cephalopod shells. The protoconch of gastropods is essentially different from that of cephalopods in that it is (at least in the majority of types) twisted into one or more coils of a spiral nature, whereas that of cephalopods, so far as known, is a mere swollen bulb. The earliest portion of the gastropod protoconch agrees essentially in form with that of the cephalopods (Spirula, Ammonoidea) and pteropods, but spiral coiling appears very early in the majority of forms. Thus the protoconch of the Gastropoda may on the whole be considered as more specialized than that of the Cephalopoda. It might perhaps be thought desirable to dignify this specialized type of protoconch by a distinct name, as has been done by Jackson in the case of the pelecypod protoconch ("prodissoconch"). If so, the name "protorteconch," suggested to me by the late Professor Hyatt, would be most applicable. The shell or conch of gastropods may be specifically described by the term "torteconch," a name also used for the spirally coiled shell of cephalopods (Turrilites, Trochoceras).

The characteristics of the protoconch of most living gastropods are very variable, as might perhaps be expected in a class whose living members are on the whole highly specialized.

FIG. 1. — *Rhopalithes rugoides* nov. gen. et sp., showing a fusoid (bulbous) protoconch with riblets on last portion and an abrupt beginning of the conch. Eocene. Paris Basin. × 10.

Even in Tertiary times this specialization of the protoconch is noticeable. It is not always possible to determine the precise line of demarcation between protoconch and conch, since in a large proportion of types the two grade into each other imperceptibly. In certain types (Buccinum, etc.) a line and a slight change in the growth of the shell indicate the place where we may most reasonably make the separation between protoconch and conch. In a number of cases (Fusus, Hemifusus, certain Murexes, etc.) the end of the protoconch is strongly marked by the existence of a pronounced varix and an abrupt change of ornamentation (Fig. 5). In the majority of cases, however, no

such definite line of demarcation exists. In general, the protoconch coils in the same direction as the conch, though conspicuous exceptions to this rule are found in Pyramidellidæ and other groups.

The early whorls of the protoconch of gastropods (except such ovoviviparous types as Cymbium) are smooth rounded coils of the type found in adult Natica, and best exemplified by *Lunatia heros* of our northern coast. In the majority of cases the initial whorl is minute, while the succeeding ones enlarge gradually and regularly. In some types the initial whorl is large and swollen (Fusus, Hemifusus, Fulgur, etc., Figs. 1, 7), when it is generally more or less elevated and oblique, a feature carried to excess in certain volutes. This type of protoconch has been termed "bulbous" by Dall.[1]

Fig. 2. — *Clavilithes rugosus* (Lam.). Eocene. Paris Basin. The apical whorls × 10, showing papillose protoconch and early conch whorls.

Again the initial whorl may be compressed so as to produce a conical form, the sloping sides of which are flat. This type, observable in so-called Clavilithes from the British and American Eocene and in some other genera, may be denominated a "trochoid" type of protoconch.[2] The flattening may be confined to the apical whorl or may be continued over one or more of the succeeding whorls. The normal naticoid type of whorl may continue, with regular increase, thus giving rise to the large "Melo" type of protoconch (Dall) so prominent in Melo and some other genera. When the whorls become depressed so as practically to lie in one plane, a "planorboid" protoconch is produced (Dall). Again the naticoid initial whorl may be succeeded by a number

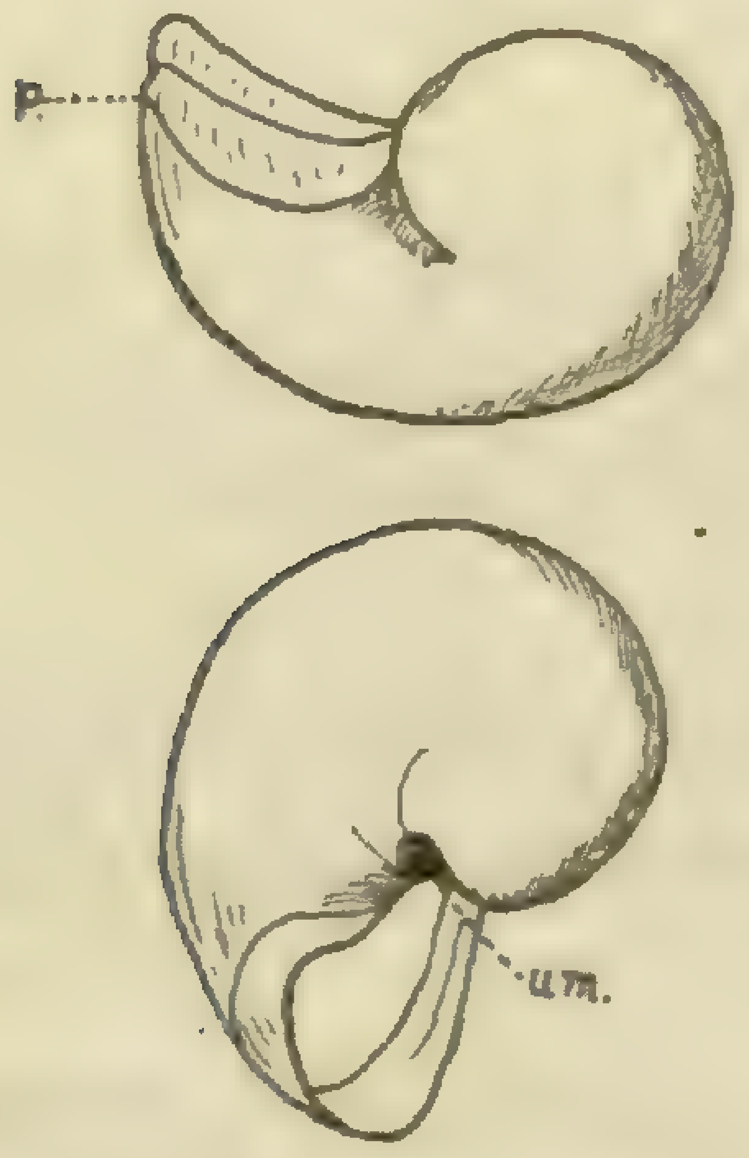


Fig. 3. — Protoconch of *Sycotypus canaliculatus*. *p*, end of protoconch; *um*, umbilicus. × 14.

[1] *Trans. Wagner Free Inst.*, vol. iii (1890), p. 67.

[2] The "trochiform" type of protoconch of Dall is more comprehensive, including the naticoid type.

of whorls which increase slightly or not at all in size, thus giving a long and slender type of protoconch which Dall has called "pupiform." This type of protoconch is characteristic of Clavilithes of the Paris Eocene (Fig. 2), of many Eocene and recent species of Turbinella, and of other forms.

The trochoid type of protoconch is apparently a case of specialization, and is confined to a comparatively small number of gastropods.

The naticoid initial whorl of the protoconch, so far as has been observed is umbilicated. This is well shown in Fulgur,

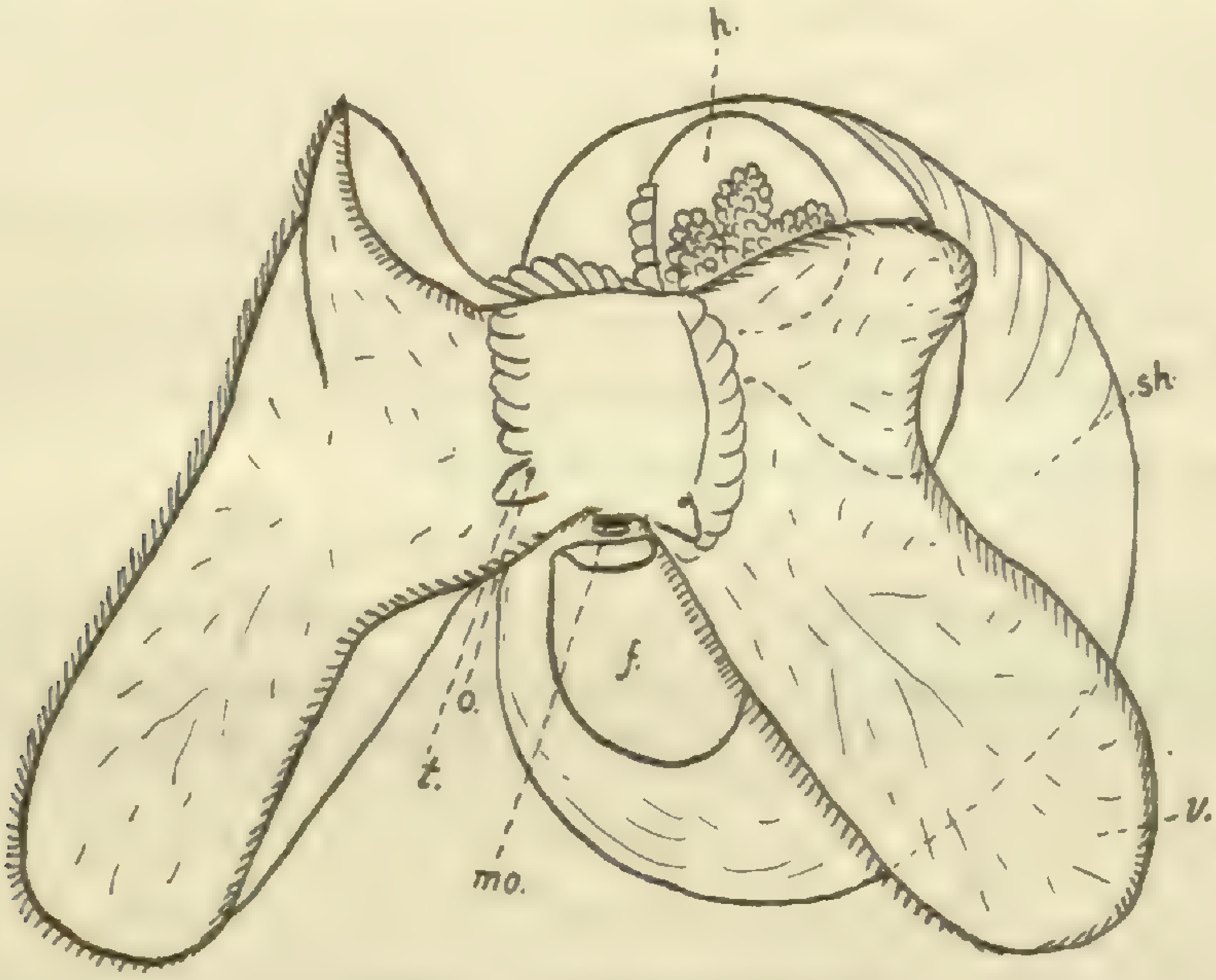


FIG. 4. — *Sycotypus canaliculatus* in the phylembryonic stage. *f*, foot; *h*, heart; *mo*, mouth; *o*, eye; *sh*, shell (protoconch); *t*, tentacle. × 30.

Sycotypus, Fasciolaria, Buccinum, and other types in which the initial whorls are large enough to be readily examined. The umbilicus is best shown in young individuals which have just completed the early protoconch stage (Fig. 3). It is well marked in Fulgur at the end of the protoconch (phylembryonic) stage, before the velum is fully developed (Fig. 4). This latter persists until just before the animal leaves the egg capsule, by which time the young conch has begun to develop and the umbilicus is closed. I believe that we are warranted in assuming that the umbilicus exists at some stage in the protoconch of the majority of gastropods, though it is conceivable that in extremely accelerated types, even this — apparently the most

primitive condition of a coiled protoconch — is lost. From the characters of the initial whorls of the protoconch we may argue that the radicle of the coiled gastropods must have been a naticoid type with a well-marked umbilicus. Such a type is found in *Straparollina remota* Billings, one of the earliest coiled gastropods of the Etcheminian or Lower Cambrian of the Atlantic border province of North America. That it is probably not the most primitive type of gastropod is suggested by the consideration that the earliest stage (ana-phylembryonic) of the protoconch is not coiled, but rather cap-shaped like modern Patella. Such primitive types are found in Lower Cambrian species which have variously been referred to Platyceras, Scenella, or Stenotheca, owing to the want of sufficient characteristics to define their exact relations.

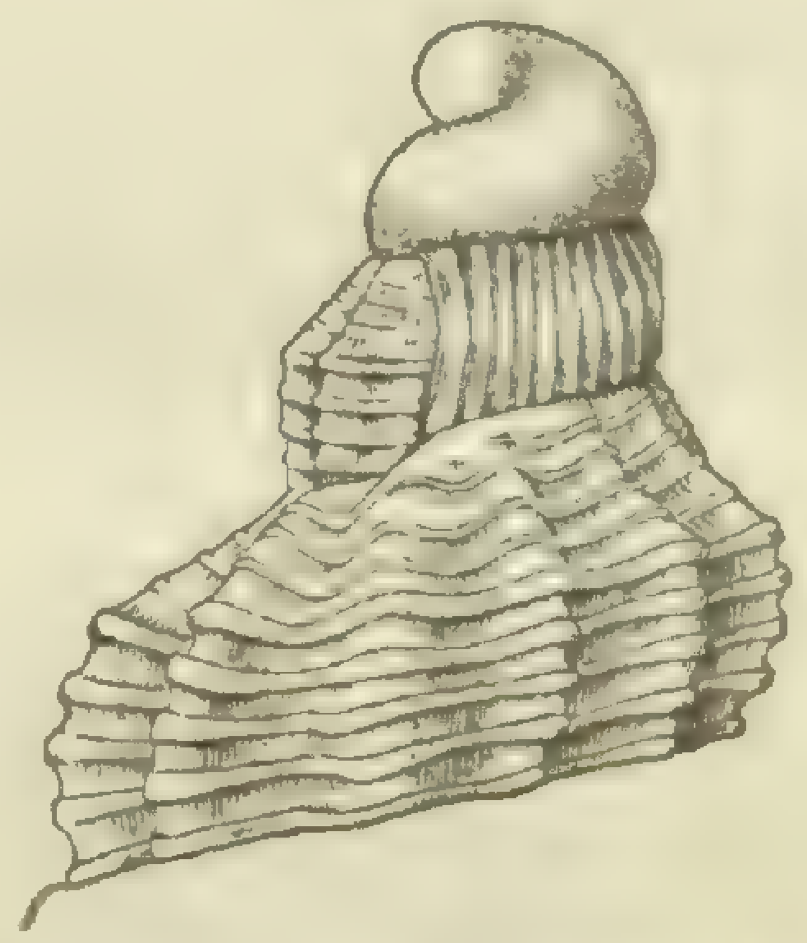


FIG. 5. — *Hemifusus colosseus* Lam. Recent. Apical whorls × 4, showing oblique bulbous protoconch with riblets in the last portion, and the abruptly beginning, accelerated conch with the shoulder developed at the beginning.

Our modern patelliform shells are probably not primitive types, as shown by the protoconchs of Acmæa and Crepidula, which are coiled.

Ornamentation of the Protoconch. — In a number of species of gastropods the later whorls of the protoconch are ornamented by riblets (Figs. 1, 5), and more rarely by true revolving lines or spirals. In others a carina appears on the whorls of the protoconch.[1] These structures normally belong to the conch, where their strength and variation constitute the chief features by which the whorls are characterized. Their occurrence on the protoconch is due to a backward pushing of the normal conch characters, until they appear on the final whorls of the protoconch. This is in conformity with the law of tachygenesis, or acceleration in development, which is the key to the understanding of the taxonomic values of shell characters in

[1] For an account of the characteristics of the protoconchs of a number of gastropods, see Baker, F. C., On the Modification of the Apex in Gastropod Mollusks, *Ann. N. Y. Acad. Sci.*, vol. ix (1897), pp. 685–704, Pls. XVIII–XX; also *Proc. Phil. Acad. Sci.* (1890), pp. 66–72; (1894), pp. 223–224; *Roch. Acad. Sci.* (1891), pp. 130–132.

gastropods. Such accelerated type of protoconch is particularly characteristic of the Fusidæ, though not confined to them. In some members of this group, *i.e.*, *Fusus caloosaensis* and its congeners, the ornamentation of the protoconch begins very early, showing extreme acceleration. This is also true of *Fusus apicalis* Johnson. Neither of these species is a true Fusus.

The classificatory value of the protoconch of gastropods has not generally been recognized, Dall, so far as I know, being the only author who has made extensive use of it. It is, however, apparent that if our classification is to express genetic relationship, this, the earliest formed portion of the shell, demands a careful consideration. It is generally conceded that organisms of a common ancestry are more nearly alike in their earliest stages of development, differentiation becoming more and more marked in later stages. This is to be expected if the law of recapitulation of ancestral characters is accepted, for then the earlier stages must more nearly represent the features of the immediate ancestor in any particular restricted group. Furthermore, the smaller the taxonomic group, the more nearly identical must be the earlier stages, since in a small group the members have not become widely separated from their common ancestor. Thus, while the initial whorl of the protoconch does not differ widely, except in size, in the majority of gastropods, indicating the characters of the more distal radicle of the class, — *i.e.*, the naticoid ancestor, — the whole character of the protoconch must be considered in the determination of the more immediate relationships. Therefore, I believe it is not too much to say that the protoconchs of all the species within a given genus should agree as to their essential characteristics, and that no species can be considered congeneric in which the protoconchs show a radical difference. Thus, as will be shown in a forthcoming memoir on Fusus and some of its allies, the American Eocene species of Fusus do not show the typical Fusus protoconch, but some have a protoconch like that of many species of Pleurotoma and like *Levifusus trabeatus* (*i.e.*, *Fusus meyeri*, etc.). Others again have the protoconch of Fulgur (*Fusus quercollis*, etc.), of which group they are the Eocene ancestors. The species referred to have adult

conch features closely similar to those of Fusus, and the consideration of these alone has caused them to be placed in that genus. (Compare Fig. 6.) These examples, however, are due to parallelism rather than close genetic relationships. Great similarity exists between the protoconchs of Fusus and Hemifusus, thus showing a close genetic relationship between these two genera, while on the other hand Fasciolaria appears to be more widely removed.

Septa in the Apex of Gastropods. — Gastropoda in which the spire of the shell is long, generally develop septa near the apex. These septa partition off the protoconch and earliest whorls of the conch, and they may generally be seen in specimens with broken apices. Turritella, Cerithium and its allies, Fusus, and in fact turreted shells in general show this septum. It is generally a curved, more or less funnel-shaped element, though often only meniscus-shaped. The septum is invariably convex backward, as might of course be expected. The apical portion is generally uniformly curved and lies freely in the cavity of the protoconch or early conch. Septa are sometimes very numerous as observable in longitudinal sections (Triton, etc.), but generally the number is comparatively small. The septa are entirely imperforate and mark the withdrawal of the apical portion of the coiled visceral hump from the apex of the shell and the cutting off of the useless space by a partition wall. In a number of types the portion of the shell thus divided off becomes invariably broken away. An interesting type of structure which belongs here is found in the recent *Scaphella magellanica* Sby. and some related forms. In this, according to Dall,[1] "the larva is clothed with a cuticular or horny protoconch, probably similar in form to that which when shelly results in the 'bulbous nucleus.' Later on, but while still in

FIG. 6. — *Fusus aster* Sow. A typical primitive Fusus. Eocene. England. $\times 1\frac{1}{3}$.

[1] Dall, W. H. Blake Gastropoda, *Bull. Mus. Comp. Zool.*, vol. xviii (1889), p. 452; *Proc. U.S. Nat. Mus.*, vol. xii (1890), p. 311, Pl. IX, Figs. 5, 6; *Trans. Wagner Free Inst. of Sciences*, vol. iii (1890), p. 67, Pl. VI, Fig. 5.

the ovicapsule, the deposition of limy matter begins as a slender cone or elevated point along the line of the axis of the protoconch, and as the larva grows the posterior part of the mantle secretes a shelly dome. Being thus cut off from the horny protoconch, the latter falls into shreds and is lost. The nucleus of the larva, still in the ovicapsule, then presents a slightly irregular dome, with a slender point rising from the apical part." To this apical point Dall has applied the term "calcarella." In this case the protoconch proper was horny and deciduous, while the first formed septum was calcareous and hence came to take the place of the protoconch when this was lost. Probably the types of nuclear whorls named by Dall "Caricella type" and "Scaphella type" from characteristic genera are secondary septal deposits of this type, as already suggested by that author.

Characteristics of the Conch. — The simplest type of whorl of the gastropod conch (torteconch) is round and smooth, showing only the lines of growth. This type, which is virtually only a continuation of the primitive protoconch whorls, is seen in Natica and similar types, and in these the umbilication is generally retained. Omitting Pleurotomaria[1] and its allies, this type of gastropod is most characteristic of the Paleozoic strata, the chief modification being the elongation of the spire, thus producing a loxonemoid type.

FIG. 7. — *Fusus porrectus* Sow. Eocene. England. Apical whorls × 10, showing bulbous protoconch and characters of early conch whorls.

One of the earliest modifications of the smooth shell is the appearance of spirally revolving, more or less elevated lines and the formation of transverse elevated folds or ribs[2] (Fig. 7). Our observations are still insufficient to settle the question as to the order of appearance of these two types of ornamentation. Where both are present the ribs in most cases are the first to appear to the unaided eye, the spirals

[1] The development of Pleurotomariidæ and Bellerophontidæ, and of Euomphalus and other related genera, has been well described by Koken (*Neues Jahrb. für Mineralogie*, Beilage, Bd. vi, pp. 305–483).

[2] These ribs must be distinguished from varices, such as occur in Scalaria, Harpa, and Murex.

not appearing visible until some time after. On the other hand, fine radiating lines — the precursors of the visible spirals — are seen in the embryonic hyaline shell of Fulgur, etc., before it has become opaque by the deposition of secondary calcareous material (Fig. 8). It is most probable, however, that these fine thread-like markings are merely due to a change in the texture of the hyaline shell, corresponding in that respect to the primitive lines of growth, and are not equivalent to the elevated spirals, whose existence is due to a regular, though slight, plication of the mantle edge which builds the shell. If we adopt this view as the most probable one, the ribs, so far as my observations go, must be considered the first modification of the shell in the ribbed and spiraled forms. It is, however, by no means true that spirals do not appear until after the ribs have been formed. In a great many Paleozoic genera ribs never occur, while spirals are well developed. This is well exemplified in the Ordovician genera Cyclonema and Trochonema, the most primitive types of which (*i.e.*, *T.* (*Gyronema*) *liratum* U. and S., etc.) are umbilicated shells of a round-whorled or naticoid outline, with spirals more or less strongly developed. Among the earliest ribbed shells of naticoid form is *Holopea pyrene* Billings from the Middle and Upper Trenton group of Canada and central United States. The ribs are scarcely anything more than coarse undulations, very like the dying stages of the ribbed condition in more highly specialized genera of later geological periods. They have, however, the chief qualities of the ribs in their most accentuated development, and must be regarded as such. As nearly as can be determined from the illustrations given by Ulrich,[1] the earliest stages are free from undulations, thus indicating that, as we

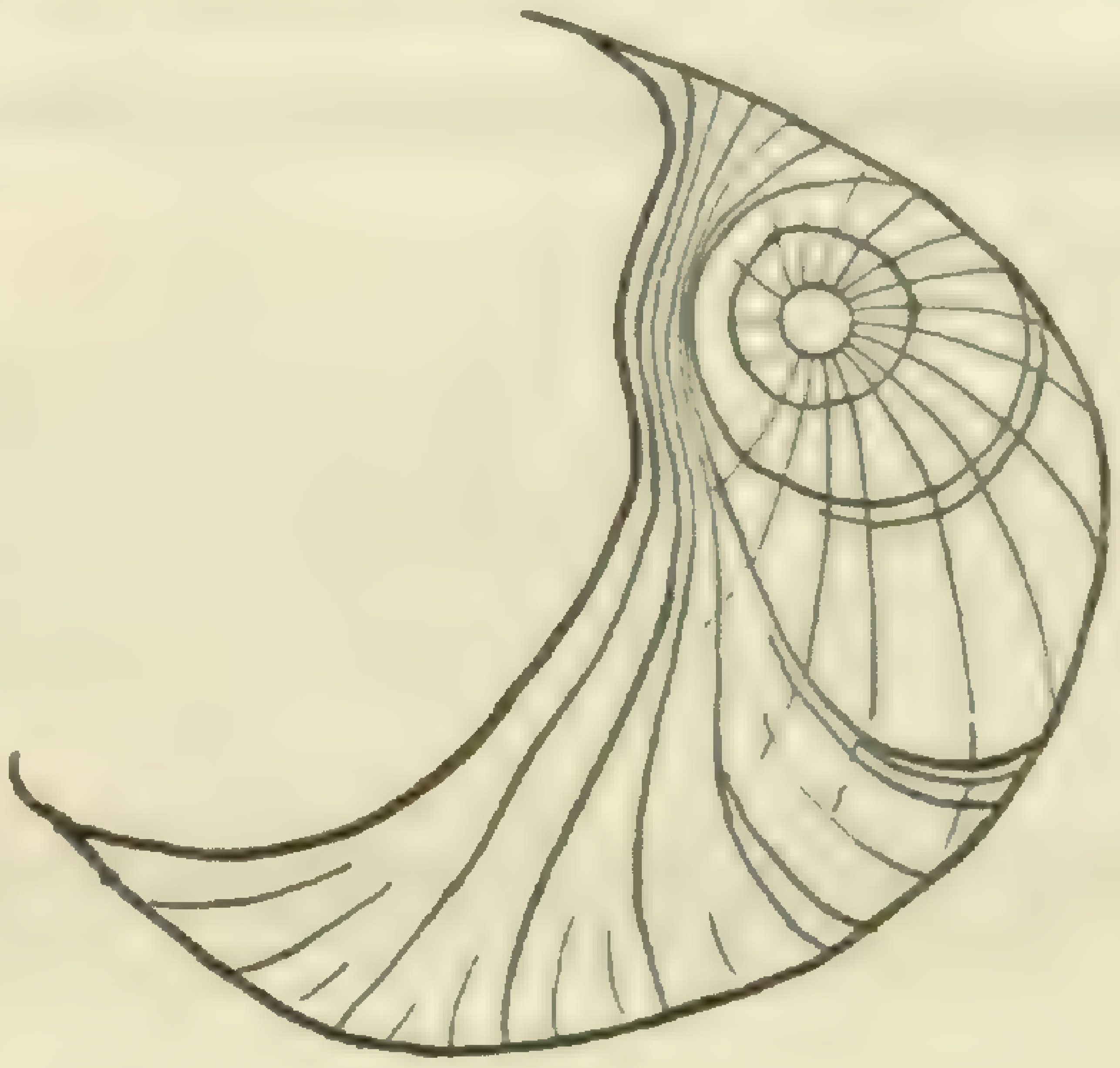


Fig. 8. — Early hyaline shell of Fulgur (Sycotypus), showing primitive lines of growth and fine radiating lines. × 48.

[1] *Palæontology of Minnesota*, vol. ii, Pl. LXXIX, Figs. 13–18.

should naturally expect, the ribbed were derived from the smooth species which precede them immediately in time. The immature specimens of *H. pyrene* illustrated by Ulrich show well the faint beginning of undulations which become pronounced only in the adult.

A somewhat more specialized ribbed shell from another phylum is found in *Natica nexicosta* Phillips of the Devonian. This in form is truly naticoid, with the ribs sharp, narrow, and uniform, separated by uniform intervals which are much wider than the ribs. The earliest stages, as far as can be judged from the illustration,[1] are ribless. The whole aspect of the last whorl of this shell is strikingly like the final whorls of the protoconch of highly specialized Tertiary and recent gastropods. *Natica subcostata* Schl. of the Devonian (Stringocephalen Kalk) of Paffrath, Germany, is another example, in which the costæ or ribs have become compound, secondary shorter ones being intercalated between the longer ones. *Natica costata* from the Lower Trias of St. Cassian carries the simple type of costæ into the Mezozoic era, while *N. armata* from the Upper Trias of that region shows the further complication of revolving spirals which are cancellated by the sharp ribs. In the later forms generally the umbilicus is closed. A similar succession of smooth, simple-ribbed, and cancellated-ribbed shells appears in Jurassic Nerita and Neritopsis, as illustrated by Hudleston in his monograph of the "Inferior Oölite Gastropoda."[2] Among the turreted types simple ribs appear in some of the Devonian Loxonemas, some species of this genus showing the further specialization of cancellating spiral lines. Similar successions may be found in a great many other series, and it is perhaps not too much to say that in the majority of the larger phyletic series, except those highly specialized, the radicle is a smooth, round-whorled form, succeeded by types in which the adults are ribbed, and later cancellated, after which progressive modification may be carried further. The index to the history of the phylum is in general to be found in the life history of the individual member under consideration as revealed

[1] Whidborne. Devonian Fauna of the South of England, *Palæontogr. Soc. Mon.*, Pl. XIX, Fig. 1.

[2] *Palæontogr. Soc. Mon.*, Pl. XXVIII.

by the succession of characters in the shell whorls, from the earliest (nepionic) conch stage to the adult (ephebic) stage.

The revolving elevated lines, or "spirals," may in general be considered as primary and post-primary. The primary ones are the first to appear, and they increase in number by the exogenous appearance of new ones on the upper and lower portions of the whorl, outside of those which appeared first. Secondary spirals appear *between* the primary ones as these diverge, owing to the uniform increase in size of the whorls. Tertiary spirals and spirals of a higher cycle appear in specialized forms, but all such forms begin with only primary spirals, and generally only a few — sometimes even only one of these. The higher cycles come in later progressively, being most numerous in the adult stage. This teaches us that in the primitive type of a series we may expect to find primary spirals only, even in the adult, and experience shows that these are characteristic of the earlier members of any series, and that they generally accompany simple ribs and simple rounded whorls. (See Figs. 6 and 7.)

The first modification in the form of the whorls in gastropod shells is generally a change from the primitive rounded outline to an angular one, which causes the division of the whorl by a median or submedian keel, or carina, into an upper, more or less flattened "shoulder" portion and a lower, generally larger body portion (Fig. 5). Sometimes more than one carina arises, in which case all except the lower portion of the whorl becomes flattened, the section assuming the appearance of a portion of a polygon. The angulation, which finally develops into a carina, and often into a more or less accentuated "keel," is generally due to the strengthening of one of the primary spirals above the others. When the shell is ribless the angulation becomes a smooth keel. This feature appears early in the pleurotomarioid shells, in which the angulation is generally accompanied by an emargination or sinus of greater or less depth, which occupies the place of the carina. This group of shells, which appears to be a very heterogeneous one, probably had its beginning in the Lower Cambrian species of Raphistoma, of which *R. attleborensis* Shaler and Foerste is

the representative in the Etcheminian limestones of the Atlantic coast region. That this species is derived from the round-whorled *Straparollina remota* of the same horizon seems probable on comparison of the species, and this is in line with the theoretic consideration which derives the angular-whorled forms from more primitive round-whorled species.

When the angulation appears far down on the whorl, so that the suture of the next whorl touches it, a trochoid shell is produced, which varies in outline from the gently tapering form of many Cerithiums, etc., where the basal angle is very obtuse, through the flat-based Trochus, where the angle is strongly acute, down to Xenophora with concave base and overhanging lateral margins, where the acuteness of the angle is extreme.

When the angle is relatively far up on the whorl, so that the body portion is the largest, we have again two types of spires produced. When the succeeding whorl joins the earlier one *below* the angle, a turreted or terraciform spire is produced, in which the length and slenderness of the spire depends on the amount of the embracing of the whorls and the obtuseness of the shoulder angle. The long graceful spire of *Fusus toreuma* and its near allies is a result of a pronounced slope of the shoulder, together with a very moderate degree of embracing of the whorls, or what might be called a slender coiling. The strong contraction of the body of the whorl below the angle accentuates the slenderness of the spire, producing what is generally called a depressed suture. In some other species of Fusus all these features are less accentuated, and the spire as a result becomes more condensed and relatively stouter, thus losing some of its gracefulness. In other gastropod shells we can study all degrees of condensation of the spire owing to the increased embracing of the whorls, the flattening of the shoulder even to right angles with the axis of the spire, and the assumption of a cylindrical form by the body of the whorl. When the later whorls embrace the preceding ones up to the shoulder angle, a uniformly sloping trochoid spire is produced, the degree of slope of which depends on the angle which the shoulder makes with the longitudinal axis of the spire. Thus we may have every gradation from the long slender spire of certain

pleurotomoid shells to the perfectly flattened or even slightly sunken spire of certain species of Conus. In this latter genus it is perceptible that even in the most flattened species the young whorls form an elevated spire, which varies in intensity of slope in different individuals. The flattened or sunken condition appears only in the later stages.

A type of modification of the whorl, which at least in appearance belongs here, is due to the formation of a notch in the

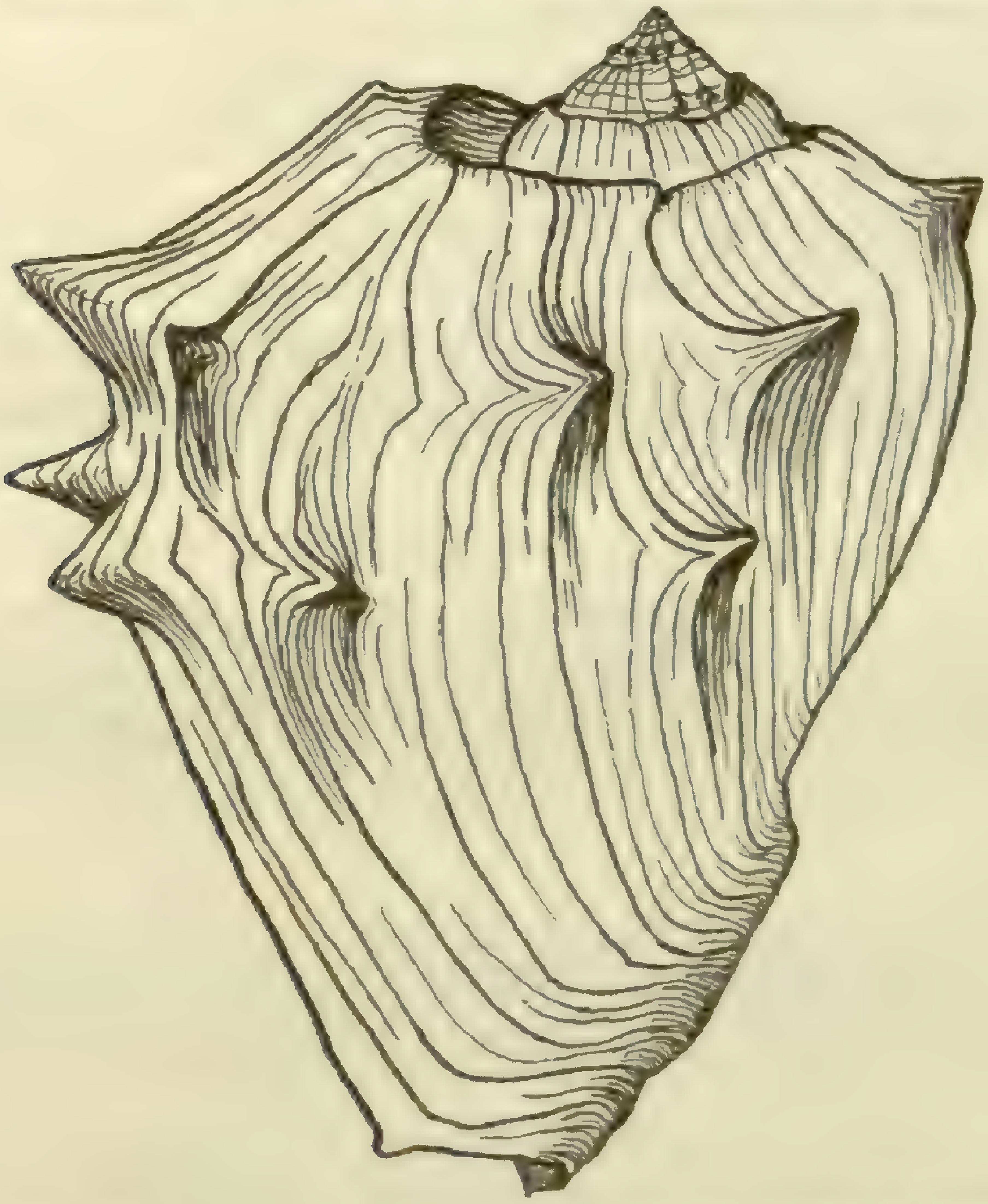


FIG. 9.—*Melongena melongena*. An immature individual, showing the melongenoid growth and the spines. Slightly reduced.

posterior margin of the aperture of the shell, where the body whorl joins the preceding one. This feature has so far been found only in the old-age stage of the individual, or in the adult or even earlier stages of phylogerontic types, *i.e.*, such as belong to a declining group of gastropods. This posterior notch may cause a transgression of the final portion of the last whorl on the spire, thus covering up a portion of the preceding whorls. This is generally accompanied by a resorption of previously formed spines or other ornamentation which would

interfere with the comfort of the animal. Accompanying the formation of this notch is generally a change in the outline and ornamentation of the last whorls, as will be discussed further beyond. This type of structure is well shown in *Melongena melongena* (Fig. 9) and *M. patula* of the modern tropical seas, and may well be termed a "melongenoid" type of growth. A striking modification of this type is seen in Strombus, where it appears only in the adult and is accompanied by the formation of a lip, and by fingers in pteroceroids.[1] This may be termed a "stromboid" type of growth. It appears periodically in Cassis, where it has the value of varices. An extreme type, the "cypræoid," is seen in Cypræa and Ovulum, where the spire is entirely covered in the adult. Still another type, characteristic of the Eocene Clavilithes and related genera, is produced by the flattening of the top of the posterior canal and the production of a flat sutural shelf, which however is unaccompanied by an increase in the amount of embracing of the whorls. This shelf thus runs like a regular spiral path around the spire part way, in rare cases almost all the way, up to the apex. This type deserves to be specified as the "clavilithoid" type of growth. In extreme cases it spreads out laterally into a flange, which in certain species is broken up into blunt, vertically flattened spines (Fig. 18).

One of the most pronounced modifications of the aperture is the formation of an anterior notch at the point most distant from the apex. This notch which lodges, and is due to the formation of an anterior mantle fold which serves the purpose of a siphon, is in many specialized types drawn out into a long slender canal, which finds its most perfect development in Fusus and in certain Murexes, where it is occasionally transformed into an almost closed tube, from the apposition of the upper borders. This type of modification makes its appearance in the Ordovician genera Subulites and Fusispira, where, however, the canal is more suggested than actually developed.

Ornamentation of the Whorls. — The simplest types of what for want of a better term we may call ornamentation of the

[1] From unpublished studies on Strombidæ, by Miss I. H. Ogilvie, it appears that the Pterocera has a polyphyletic origin.

whorls are, as already suggested, simple ribs, or spirals, or both. When the whorls remain round throughout the life of the individual no other regular ornamentation is as a rule produced, except that in the final (gerontic) portion of the last whorl the ribs, and in some cases the spirals, may disappear, leaving the shell smooth. If, however, a shoulder is produced through the formation of an angulation, a new succession of ornamental types will arise, which generally appears in the same sequence in widely separated groups of gastropods. The first effect of the angulation seems to be to concentrate the growth force on it. The ribs become accentuated on the angle, and correspondingly fainter away from it. Finally, they disappear above and below the angle, being represented on the latter, however, as a series of tubercles. These tubercles, though generally blunt, may at times assume a somewhat spinous form ; but they appear to be distinct from true spines, which, so far as observed, are a feature of later growth. In the cases in which actual succession has been traced out in series (Fulgur, Fusus, Hemifusus, etc.) it was found that the knobbed or tuberculated stage is succeeded by a stage in which the tubercles become confluent, producing a pronounced ridge or keel on the angulation. This after a time disappears, and with it the angulation, the outline of the whorl becoming rounded again, with only the spirals persisting. These in some cases may disappear also, or at least become very faint. After the whorl has returned to its primitive rounded outline a new type of modifying element arises in the form of spines. These begin as notches in the margin, generally in the spiral zone of the angulation of the earlier whorls, but sometimes in a second or even a third zone lower down on the body of the whorl (*e.g.*, Melongena). They mark a distinct and periodic fold in the outer lobe of the mantle, which sometimes is accompanied by a temporary cessation in shell building, as indicated by more or less strongly marked resting lines in the lines of growth of the shell (*Fulgur carica*, etc.). They thus have all the characters of varices of the type so pronounced in Murex, where their multiple development and frequent compound character produce the most striking feature of the group of shells generally associated

under that generic name. When the spine has been fully developed, the fold in the mantle which caused it may gradually diminish in size, with the active resumption of the shell-building process, until it finally disappears. In this case the spine is gradually closed on the apertural side, thus becoming symmetrically developed (Fulgur, Hemifusus). In some cases, however, the fold of the mantle appears to be lost abruptly when the shell-building process recommences. In such cases the apertural side of the spine remains open, becoming entirely external by the flooring over of the emargination produced by the spine in the shell margin. This type is most characteristic of the spines forming the varices of Murex.

Through a process in acceleration in development, which will be more fully discussed below, the spines may be crowded backwards, *i.e.*, appear earlier and earlier, thus condensing the preceding stages more and more until finally some of them are dropped out altogether. Thus it will eventually happen that as in *Fulgur carica* of the recent fauna the keeled and smooth stages are dropped and the spines follow immediately upon the tubercles, and to some extent even encroach on these. A gradual passage from the true tubercles to the true spines is thus produced, and it becomes practically impossible to determine where one type ends and the other begins. This feature may be readily observed in the various species of Hemifusus, in most of which varieties occur showing all stages from the widely separated tuberculated and spinous stages to those in which spines and tubercles grade into each other without allowing a line of demarcation to be drawn. In trochoid and other shells in which the whorls embrace up to the angulation, the spines, if present, are either imbedded in the succeeding whorl and more or less covered up, or else they are progressively resorbed as the new whorl increases. In Melo and some other genera the spines project upwards and are generally unclosed on the apertural side. This produces the spiral "corona," so striking a feature in some shells. Finally, the remarkable apical character of *Yetus* (*Cymbium*) *proboscidialis* should be mentioned. In this a depressed, smooth, central, apical area occurs, due to a secondary deposit which covered

up all the preceding whorls. This is margined by a sharp elevated and thin edge.

Varices. — Varices are the periodic rows of spines, or the reflexed or bent-over lips which mark recurrent stationary periods in growth in many gastropod shells. Several types may be recognized, — the spinous, *e.g.*, Murex, the simple reflexed lip, best shown in Scalaria, and the periodically accentuated normal rib, perhaps the most abundantly represented type. The simplest type of the spinous varix is that in which each stopping place is marked by only one simple spine. Such a condition, found in Fulgur and a number of other genera, is generally not considered as falling under this category ; but it is clear that the multispinous varix is a modification of the unispinous one. This becomes more apparent when we note that in every multispinous varix one of the spines predominates over the others to a greater or less extent. On tracing back the spiral from which this spine arises, which is generally possible, even though the lower spines are progressively resorbed by the advancing inner lip of the new whorl, it appears that in every varix it bears the largest spine. Finally, on tracing back far enough, only one spine is seen on the whorl, — the primary spine, which throughout is recognizable by its predominant size. In *Murex brassica* Lam. of the west Mexican coast we have a type in which only a few additional small spines occur besides the primary large spine. This is but slightly advanced beyond the state found in Fulgur. In *M. bicolor* the shell continues to grow somewhat after the chief varix is formed, the principal spine alone remaining unclosed, so that the lip at the resting stage differs little from that of Fulgur. The multispinous type of varix, with simple spines, is best illustrated in the beautiful *Murex tenuispira* Lam., the most striking in form of all the Murexes. Each spine arises from a spiral line, of which it forms the apertural prolongation. The shorter spines arise from the secondary spirals, and on the canal they are bent at about 120° forward from the primary ones, thus lying parallel to the primary series of the next but one varix preceding. Only in the neighborhood of the large spine do the tertiary and even later cycles of spirals terminate in small spines.

If the spine from a primary spiral does not increase in length rapidly, but increases in width, the secondary and later spirals, instead of developing independent spines, encroach upon the primary one and modify it by the production of lateral crenulations, which, as the spine grows, diverge more and more and become more and more pronounced, until the striking multi-lobed character of the spine of *M. palma-rosæ* (Lam.) and other highly ornate species is attained. If the principal spine of such a species is traced backward through preceding varices (which can generally be done, since resorption does not reach up to it), it will be found to be less and less complex in earlier and earlier varices, and ultimately may perhaps — in a very perfect specimen — be resolved into a single spine. (See Fig. 10.) In the growth of the spine itself, from its beginning on the final or first varix (counting backward) to its full development, as already noted, it progressively increases in complexity. A stage somewhat earlier than the adult stage in this spine shows the same degree of complexity as the *adult* of the representative of this spine in the next preceding or second varix. A still earlier stage in the principal spine of the first varix corresponds to the stage just preceding the adult in the principal spine of the second varix, and to the adult stage in the corresponding spine of the next earlier or third varix, and so on. In the same manner, though less perfectly developed in most cases, the spine next below (anterior of) the principal spine on the final or first varix has the characters of the adult of the principal spine in the next preceding or some earlier varix, and the third spine has the adult characters of the principal one in a still earlier varix. The last spine of the final varix — presumably the last formed one — has the characters of the principal spines in one of the earliest varices, when the shell was still very young (Fig. 10, where *A-10* corresponds to *K-1*, and *B-10* to *L-1*). Thus each spine passes through a succession of stages, and in its reappearance in a new varix it has made marked advances. The life history, therefore, of a single spine may be read by noting the characters of all the spines of that varix progressively from the smallest to the largest. This also indicates in general the life history of the group to which the

species under consideration belongs. Thus in an ancestor of *M. palma-rosæ* we might expect that the principal spine on the last formed varix of the adult shell would have the characters of this same spine in an earlier varix in *palma-rosæ* or those of a more anterior spine in the adult varix of that species. Such correspondence of characters in localized areas (*e.g.*, a single varix), with the changes characteristic of the life history of the group, has been called by Jackson the formation of localized

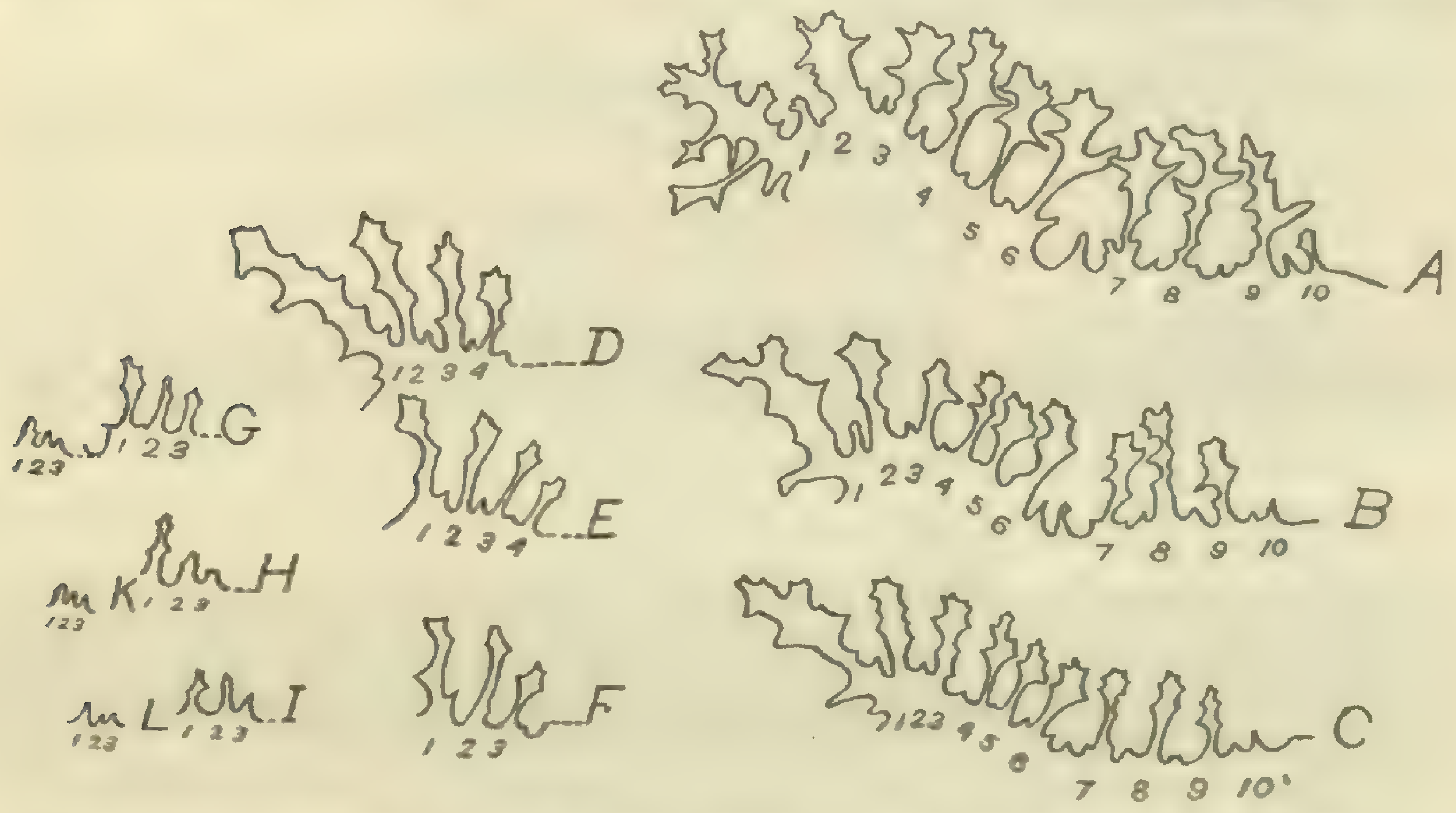


Fig. 10. — Diagram of the varices of *Murex brevifrons* Lam., from the West Indies. *A* is the last or most recent varix, *L* the earliest recognizable one. The corresponding spines are numbered alike. The dotted line indicates that the remaining portion has been resorbed.

stages in development, and he has found this phenomenon in a great many types of animals and plants.[1]

One of the commonest types of varix is that due to accentuation of normal ribs. Even in the spinous Murexes the bases of the spines are merged in such an accentuated rib, which recurs with greater or less frequency, though with regular periodicity, in the various species. This accentuated rib, whether spinous or not, appears to mark the periodic culmination of constructive vitality, after the expenditure of which a rest is necessary before building again commences.

The varices of Harpa are due to a periodic reflection of a smooth lip, which has the appearance of a margin rolled back.

[1] Jackson, R. T. Localized Stages in Development in Plants and Animals, *Mem. Boston Soc. Nat. Hist.*, vol. v, No. 4.

In Scalaria the varices are simple labial flanges, which stand out as sharp ridges, with the appearance of ribs. In *Helix albolabris* and other types the varix is formed only in the adult. In all types with successive varices it may be observed that the varices of the same longitudinal zone do not form a line parallel to the axis of the shell, but that this line runs spirally backward, in the direction opposite to that in which the whorls coil (Fig. 12). This is due to the fact that there is a progressive diminution in the proportional amount of building which was performed between the resting stages. If the amount of building were proportional to the size of the shell, the varices would run in straight, constantly diverging lines (Fig. 11) instead of spiral ones. If the proportional increase were too great for the size of the shell, and progressively increasing, the lines of varices formed by the corresponding ones of all the whorls would pass spirally forward, *i.e.*, in the direction of coiling of the shell. Neither this nor the case of increase proportional to the size of the shell has been noted, and it hence appears that we have here an illustration of Minot's law of senescence, the animal progressively growing old from the beginning. This feature is best shown in Scalaria, where in large specimens an additional feature, first pointed out to the writer by Prof. R. T. Jackson, is also seen. This is the more rapid shortening of the building stages, in the old age of the individual, so that the varices of the last — old age — whorl are not continuous with those of the preceding ones but fall between them, so that sometimes a varix may be the whole length of a period behind what it should be (Fig. 13). In phylogerontic species of Scalaria this feature appears in the adult or earlier whorls,

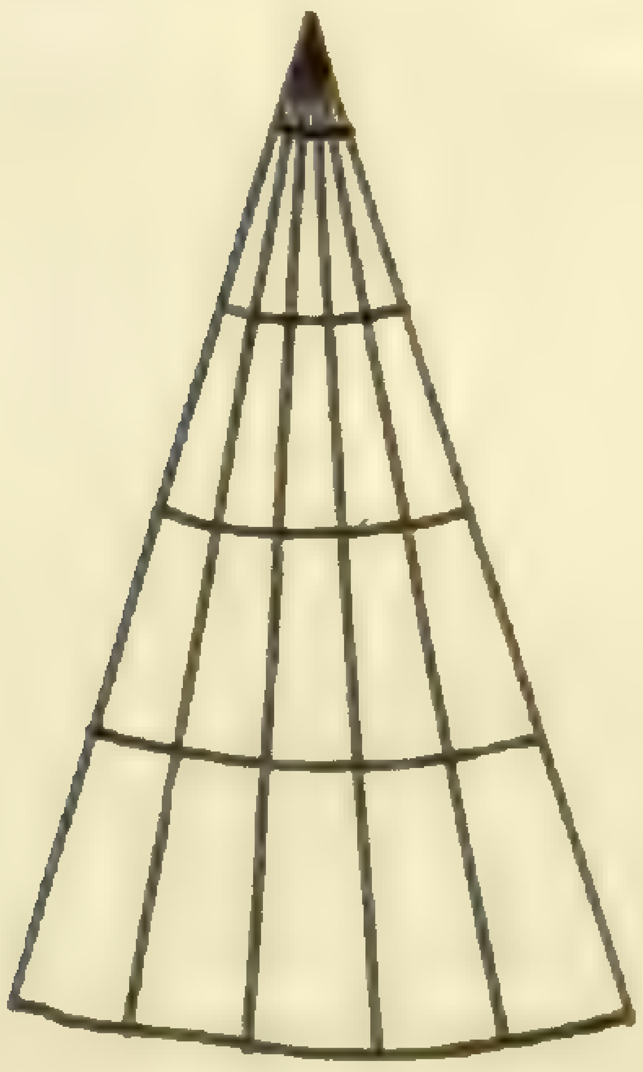


FIG. 11. — Diagram illustrating hypothetical varix growth, with uniform proportional increment.

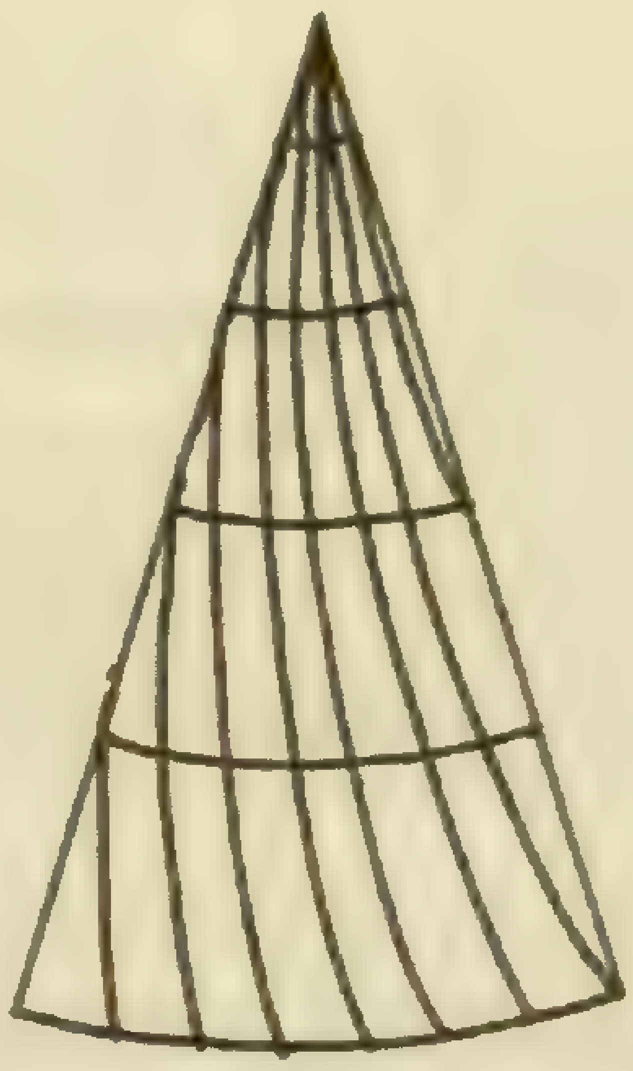


FIG. 12. — Diagram of the characteristic retarded growth between varices.

which whorls will then have a larger number of varices than those preceding them.

Other Ornamental Features.—Dall[1] has demonstrated the purely mechanical origin of the columellar plication in gastropod shells to be due to the sliding inward and outward over the columellar surface of a mantle lobe folded by being crowded into too small a space. In Cypræa these plications are most numerous and developed in the adult on both sides of the aperture. The intensity of the plications varies with the nearness or remoteness of the muscle of fixation. In a like manner the liræ of the outer lip may be explained. We must, however, be careful not to mistake the strong spirals, which sometimes appear through the thin covering of the inner lip, for plications, or the interspiral spaces appearing prominently in the thin outer lip, for liræ. Countess von Linden has discussed at length the development of the color pattern in gastropods,[2] and the reader is referred to her paper.

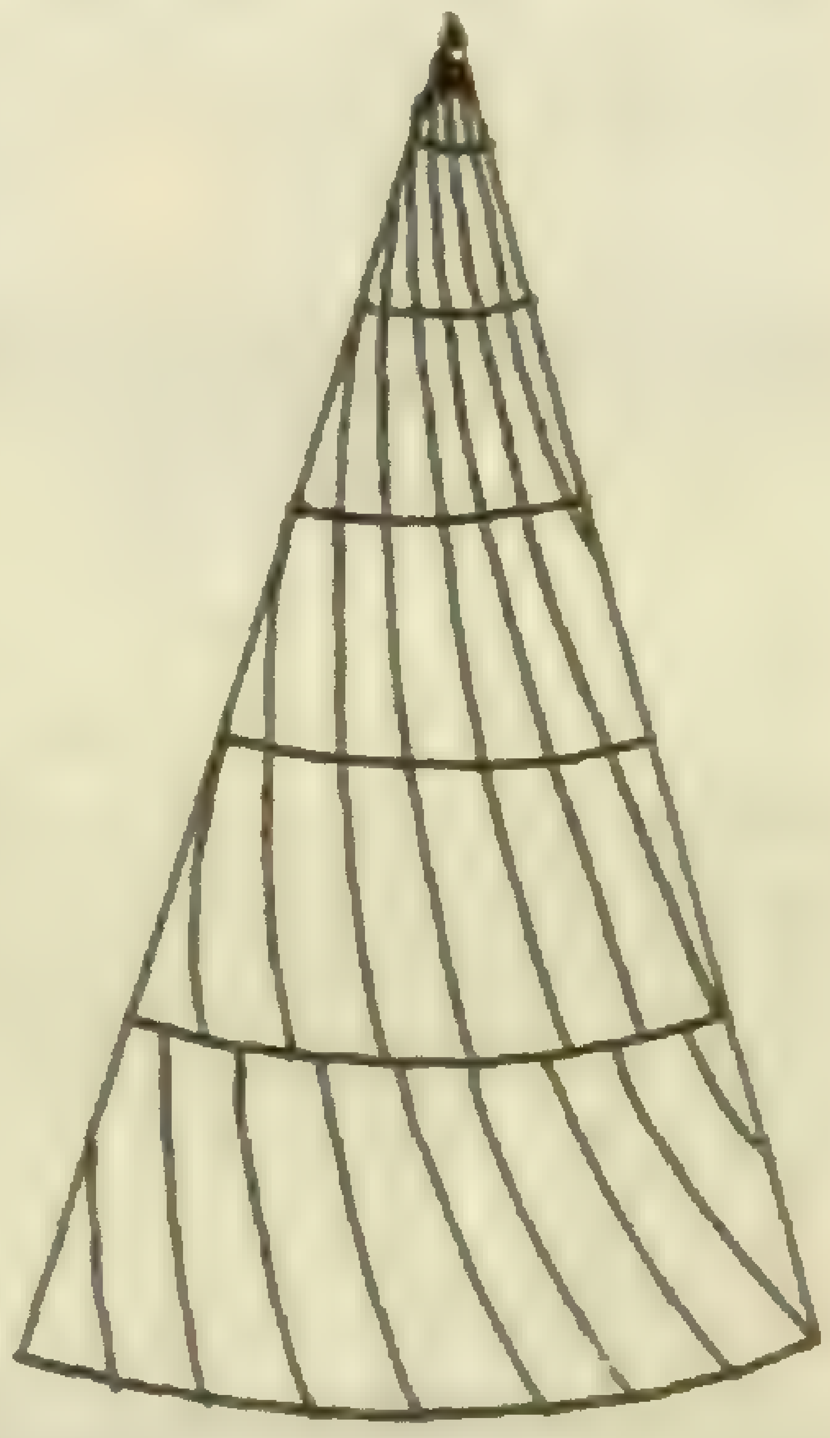


Fig. 13. — Diagram illustrating gerontic characters in the varices of the last whorl.

Individual Old Age, and Phylogerontic Characters in Gastropods. — Gerontism, or old age, is marked in its earlier stages in gastropod shells by the disappearance of features characterizing the adult. Such disappearance of features is generally in the reverse order in which they were formed. In the fusoid types the shoulder and the spines are the first to be lost, if they have been developed; or if there were only spinous tubercles, as in the Fusidæ, these disappear together with the angulation, and the gerontic lip becomes smooth except for the spirals. The normal outline is next more or less modified by an attempt at straightening out the whorl and making it more cylindrical,

[1] *Loc. cit.*, p. 58.

[2] von Linden, Maria. Die Entwicklung der Skulptur und der Zeichnung bei den Gehäuseschnecken des Meers, *Zeitschr. für wissensch. Zoologie*, Bd. lxi, pp. 261–317. 1 pl.

producing a consequent obscurity of the canal. The last stage in gerontism is observed in the loss of the power to coil, which is at first expressed in the separation of the inner lip from the columella; and if any further coiling occurs, in the loose apposition of the whorls and the consequent formation of an umbilicus. These features never go very far in the normal gerontic individual, for death intervenes and ends the process.

Among the highly specialized types of gastropods uncoiled phylogerontic species are relatively uncommon. Perhaps the most striking example in a highly specialized group in which such a want of regular coiling does exist in the adult is Vermetus. This, as is well known, has all the characters of a Turritella in its young stages, showing its derivation to be from that group. In the adult, however, it loses the power to form a regular spiral, turning and twisting in all directions and completely uncoiling at times, so as to make these portions of the shell almost indistinguishable from worm tubes such as Serpula. In primitive gastropods non-coiling, through the loss of the power to coil, appears to be the normal expression of old age, or gerontism, since in most cases the coil is the only feature which can be modified.

Shells with the final portion of the coil unrolled are well represented in the Ordovician. They even occur in the Cambrian, as indicated by *Platyceras primævum* Billings from the Lower Cambrian. From what is known of this little shell it appears that it represents a strongly umbilicated, low-spired naticoid type, with a portion of the last whorl free. If, as appears to be the case, the early whorls are normally coiled, and only the later coil loosely, this little shell represents the first phylogerontic type appearing side by side with the naticoid radicle of the entire group of gastropodous mollusks. Leaving out the loose coiling Eccyliomphalus and Eccyliopterus as of questionable affinities, the first well-pronounced example of a phylogerontic type with the final whorls not coiled is found in the Ordovician pleurotomarioid genus Lophospira. This genus, which comprises mainly normally coiled umbilicated forms, contains a few species which have become phylogerontic and show various degrees of non-coiling (Fig. 14).

Trochonema vagrans Ulrich and Scofield (Fig. 15), from the Stones River group, represents a phylogerontic type among the carinated naticoid gastropods, while *Dyeria costata* (James), from the Upper Lorraine of Cincinnati, represents a phylogerontic type of the group of simple naticoid shells with depressed spire. In the Silurian, *Platyostoma* (*Diaphorostoma*) *niagarensis* frequently shows individual gerontism by a loose outer lip. *Platyceras niagarense* represents a phylogerontic type, possibly derived from the former. In the Devonian the phylogerontic non-coiling Platycera abound. We find all degrees of coiling, from the close-coiled non-umbilicate Diaphorostoma, which appears with slight modifications throughout most of the series, to the straight "Orthonychia," which appears as a terminal member in most groups. Very often a number of species of "Platyceras" can be traced to a species of Diaphorostoma or Strophostylus occurring with them, the gradations being perfect. From such evidence it appears that the numerous species classed together as Platyceras must be split up into groups, each of which has been derived from a close-coiled ancestral species, probably within the same geological horizon. If so, the name Platyceras becomes meaningless for generic purposes. The great difficulty which besets the proper breaking up of what appears most certainly to be a group of polyphyletic origin lies in the small number of ornamental characters which can be made use of in tracing out relationships. In many Platycera spines appear, but these cannot be regarded as clues to affinity, since spinous types may and do arise in any group. What seems to be the right method of procedure was made use of in the

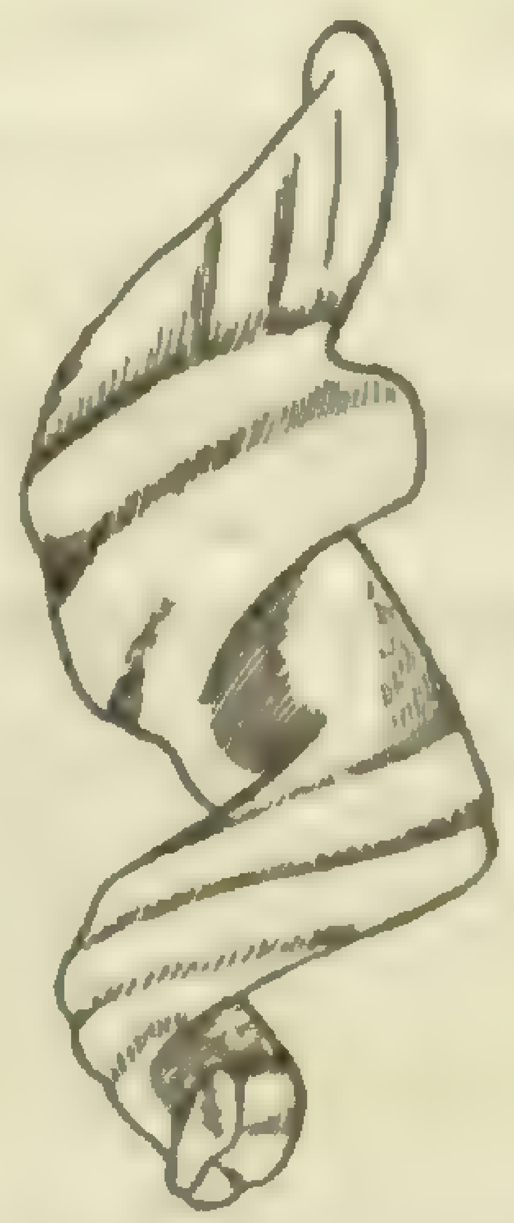


FIG. 14. — *Lophospira helicteres* var. *wisconsinensis* A. and S., showing loose coiling. (After Ulrich, *Palæontology of Minnesota*, vol. ii, pl. lxxii, Fig. 26.)

FIG. 15. — *Trochonema vagrans* U. and S., illustrating gerontic final whorl. (After Ulrich, *Palæontology of Minnesota*, vol. ii, pl. lxxviii, Fig. 13.)

determination of the genetic relation of *Platyceras arkonense* Shimer and Grabau, from the Hamilton of Ontario.[1]

Natica neritæformis, from the European Muschelkalk (Queenstedt), as far as can be judged from the internal molds which are alone represented, is a phylogerontic member of a simple naticoid group of shells. Fissurella, Acmæa, and other patelloid types, so common in the Mezozoic and modern sea, have, as already noted, a coiled protoconch. They therefore represent phylogerontic types, in which the power of coiling has been lost after the completion of the protoconch stage. In Crepidula the power to coil is still retained in a slight degree. In the majority of specialized gastropods phylogerontism is expressed, not in the non-coiling of the last portion of the spire, but in its expansion and wrapping about the earlier whorls so that these become more or less concealed. This is generally accompanied by the loss of all ornamental characters except, in some cases, the coloration. Sometimes it happens, however, that spines arise independently on this portion of the shell. This is most marked in Melongena and can be readily explained by the peculiar manner in which the shell develops.

In the young stage every typical Melongena has the characters of Hemifusus. In accelerated species of this genus spines follow the tubercles, the two grading into each other as in *Fulgur carica*. In other species, however, notably *H. colosseus* Lam. and *H.* (*Melongena*) *pugilinus*, a keeled or even smoothly rounded stage intervenes between the tubercled and spinous stages. (See *ante*.) This enables us to understand Melongena.[2]

The two typical species of this genus appear to have been derived from the same ancestral species, which coexists with

[1] Shimer, H. W., and Grabau, A. W. The Hamilton Group of Thedford, Ontario, *Bull. Geol. Soc. Am.*, vol. xiii, p. 176.

[2] Only the two typical species, *Melongena melongena* and *M. patula*, are referred to here. Most of the other species generally referred to this genus belong elsewhere. Such species as *M. morio* and *M. pugilina* are transitional from typical Hemifusus, *e.g.*, *H. colosseus* Lam., being produced chiefly by a condensation of the typical Hemifusus characters. They are generally classed with Melongena, but have not the typical phylogerontic growth of that genus. They will be referred to under both names.

them, — namely, *Hemifusus* (*Melongena*) *morio*. Representatives of this species occur in both west African and West Indian waters. From the west African type appears to have been derived the Mazatlan species *Melongena patula*, while *M. melongena*, at home in West Indian waters, was derived from the West Indian representative of *H.* (*M.*) *morio*. In both species the phylogerontic melongenoid form of whorl appears immediately after the tubercled and before the spinous stage, this latter coming in somewhat later. Thus, while the mode of coiling has become senile, the formation of the spines indicates

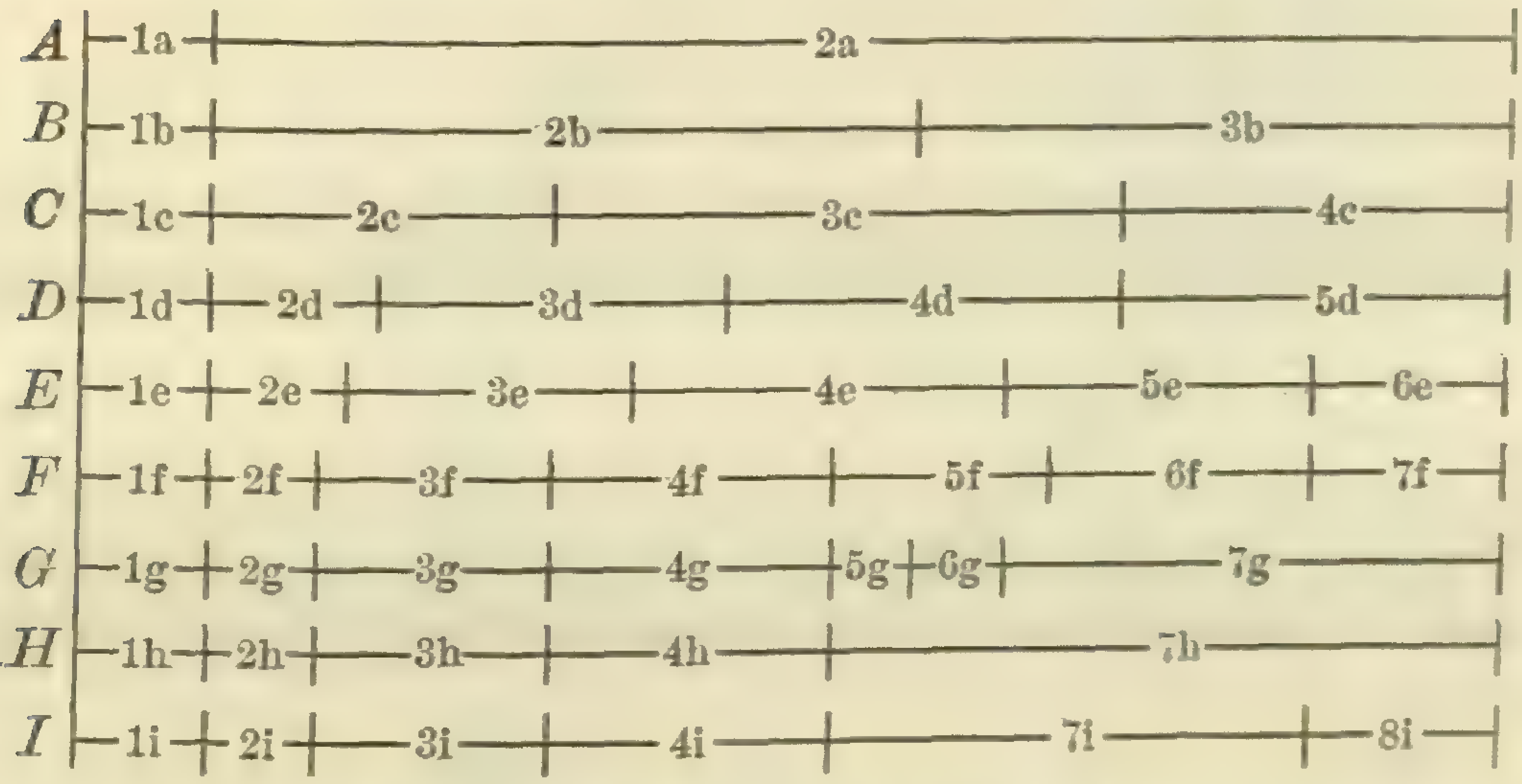


FIG. 16. — Diagram illustrating Hyatt's Law of Acceleration in Development. For description see text.

the persistence of one portion of the vigor of the adult. Such form of acceleration may be called partial or incomplete, differing in that respect from Fulgur, in which the acceleration is complete. A reason for this may perhaps be found in the following consideration: Fulgur is an accelerated type in the present fauna. The species in which a separation existed between the tubercles and spines all lived in Miocene and Pliocene times, and hence in the modern descendant (*F. carica*) spines have become firmly established. We may further suppose that the power to form spines has persisted so long that in the adult it is on the wane; and hence if any phylogerontic types of Fulgur should arise, the spines would first disappear and probably would never be formed again. In Hemifusus, on the other hand, the spine-forming power has

apparently been but recently acquired, judging from the frequent lateness in appearance of spines in individuals. Thus there would be more vitality or spine-forming power left, which would be able to overcome any weakening effect of senility appearing in other features of the group. Hence, though a gerontic form of coiling is assumed by the whorls of Melongena, the power to form spines is still retained, and these appear after an interval in the senile portion of the whorl.

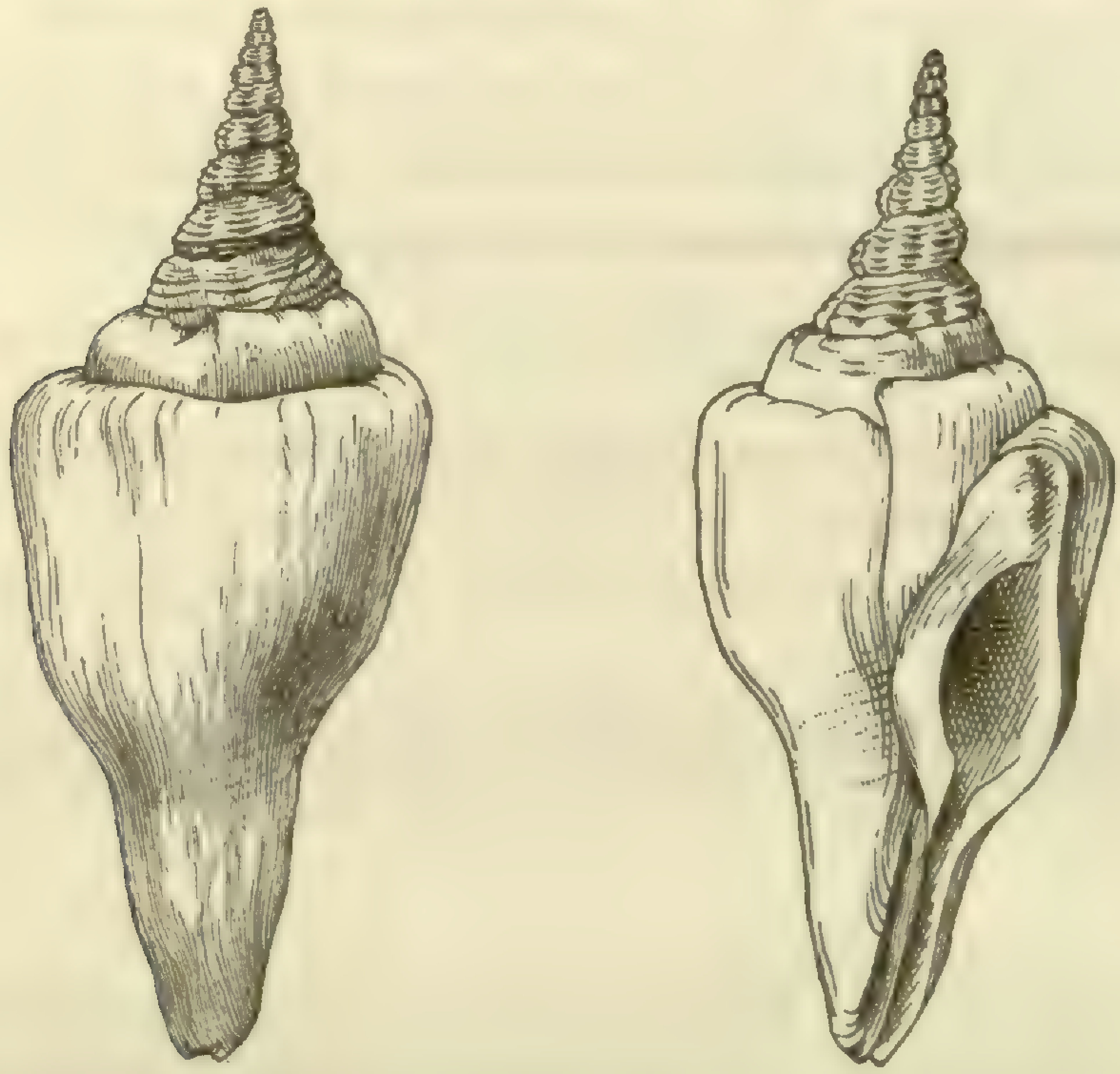
Illustrations of the Law of Tachygenesis and of Parallelism among Gastropoda. — Hyatt's Law of Tachygenesis, or acceleration in development, teaches us that the adult characters of a species are inherited at an earlier stage in the members of a succeeding generation. This of course implies a condensation of preceding characters, which in some cases may even be dropped entirely. The diagram on page 941 (Fig. 16) will give a clearer representation of the working of this law.

Let each of the lines *A* to *I* represent the life history of an individual gastropod in a phylogenetic series, beginning with *A*. Let the life history be divided into stages numbered from 1 up, each stage being characterized by some definite feature in the shell.

No. 1 is the protoconch stage, which persists throughout; No. 2, the smooth, round, whorled naticoid stage; No. 3, the primitive ribbed and spiraled stage; No. 4, the angular stage, with formation of nodes at the crossing of the ribs; No. 5, the keeled stage; No. 6, the second round-whorled stage; No. 7, the spinous stage; No. 8, the spineless smooth stage.

It becomes apparent that as new characters appear, the older ones persist for a shorter and shorter time. This is necessary, for otherwise each succeeding species must be larger to accommodate the new characters. This is acceleration by condensation. A character newly acquired in one member of the series appears earlier and earlier in the succeeding members of that series, thus changing from an adult to an infantile character. Some characters are less resistant than others, and these will be more quickly condensed. Such is the case with those of stages 5 and 6, the keel and the second round-whorled stage. The nodes are very persistent, and the

spines (of stage 7) are very vigorous. Thus it will happen, as in *H*, that stages 5 and 6 are dropped out altogether, stage 7, the spinous one, following upon stage 4, the tubercled



FIGS. 17 and 17 *a*. — *Cyrtulus serotinus* Hinds. Recent. A phylogerontic type of the Fusus series. Natural size.

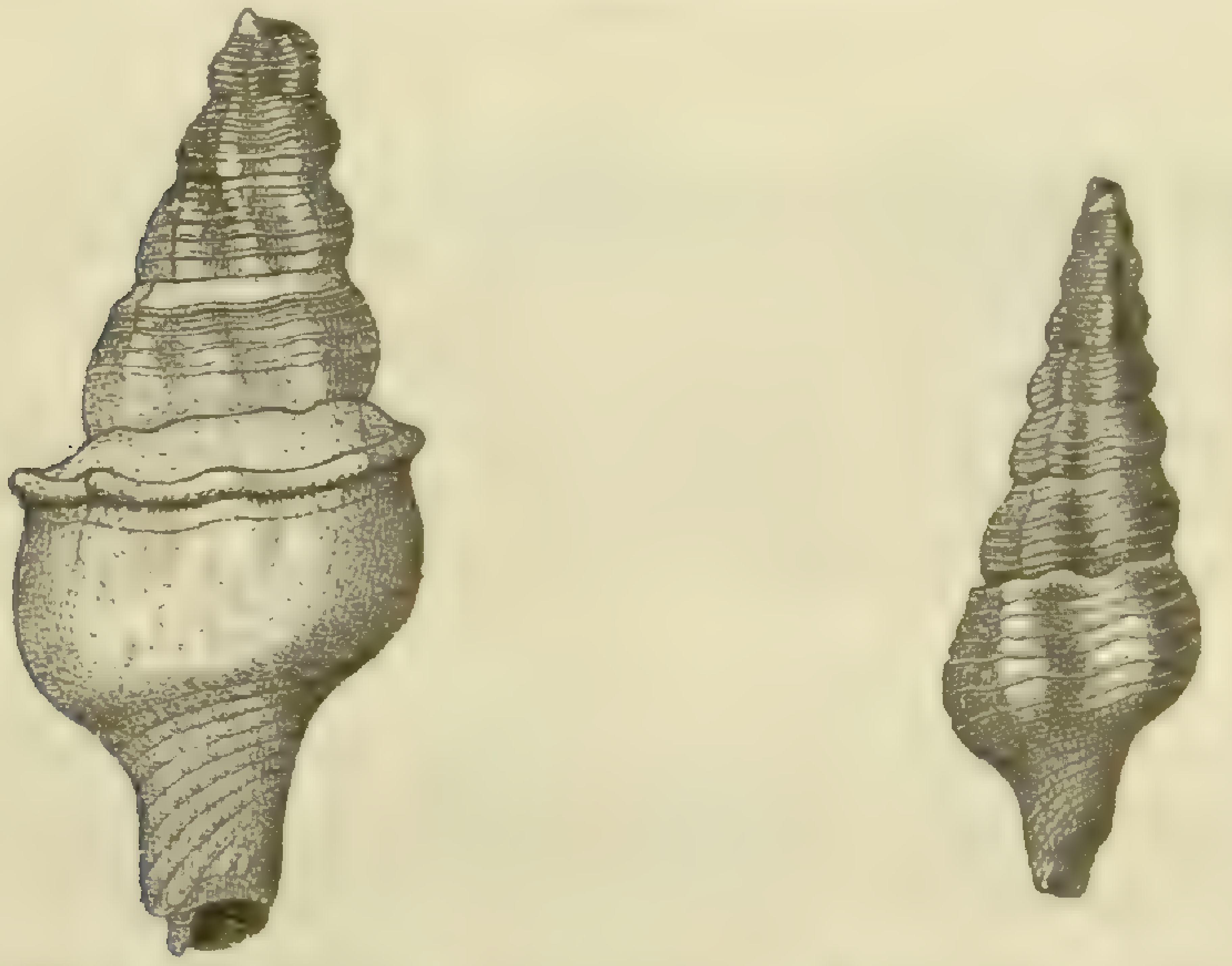


FIG. 18. — *Clavilithes chamberlaini* Johnson and Grabau. Eocene. Texas. Two stages; the adult showing a serrated flange and clavilithoid form. (*Proc. Phil. Acad. Nat. Sci.*, September, 1901.)

one, and even encroaching upon it. This is acceleration by elimination (example: *Fulgur carica*). Finally, even the vigorous spines disappear, and the final smooth gerontic stage is formed.

Parallelism. — There are perhaps few if any classes of invertebrates which equal that of the Gastropoda in illustrating the law of parallelism of development. In the Gastropoda similar features constantly arise independently in entirely distinct series; and since these features are generally used as a basis of classification, it follows that our present system of classification is in great need of revision. If we represent the natural system of classification by the customary tree and its branches, and then pass a more or less warped plane through the upper part of this tree, intersecting each branch at the same relative stage of development, we obtain a number of scattered points where the plane and the branches intersect. If we consider these points species, and group all the neighboring and perhaps some distant points into genera and so on, we will get very much what we have to-day in the classification of marine gastropods. In point of fact, we have only one episode in each of the large number of distinct phyletic series, and what we mistook for relationship is only a resemblance in a parallel developing series which has been cut at the same stage in development. Thus it is clear why the customary mistake of placing the recent *Cyrtulus serotinus* (Figs. 17, 17*a*) with its parallel, the Eocene Clavilithes, is so generally made. Both are phylogerontic members of entirely distinct phyletic series, but they have reached the same stage in development. Again Fusus, known only in the Eocene of Europe, and in this country only from the Miocene on, has its close parallel in Pseudofusus and other genera in the American Eocene. Here the same type of form is developed, — a very simple matter, — but, as shown by the life history, the two types are widely apart genetically. Again, all gastropods with stromboid lips are placed with Strombus, a proceeding which has no warrant from a phyletic point of view. The common proceeding of classing all loose coiled or non-coiled Paleozoic gastropods under Platyceras has likewise no warrant from a phyletic view point, though it must be confessed that this is a convenient method when we do not know what else to call them. Thus, without multiplying examples, we may sum up the result of our studies in the words of Hyatt's Law of Morphogenesis: "A natural classification

may be made by means of a system of analysis in which the individual is the unit of comparison, because its life in all its phases, morphological and physiological, healthy or pathological, embryo, larva, adolescent, adult, and old (ontogeny), correlates with the morphological and physiological history of the group to which it belongs (phylogeny)."

PALÆONTOLOGICAL LABORATORY,
COLUMBIA UNIVERSITY.

THE OCCURRENCE OF FORMICA CINEREA MAYR AND FORMICA RUFIBARBIS FABRICIUS IN AMERICA.[1]

WILLIAM MORTON WHEELER.

In a valuable paper published in 1886[2] Dr. Gustav Mayr recorded both *Formica cinerea* and *F. rufibarbis*, two well-known European ants, as occurring in the United States. The former was cited from California and New Mexico, the latter from Colorado, Nebraska, California, and Montana. Seven years later, when Professor Emery published his important revision of the North American Formicidæ,[3] he was so doubtful of the occurrence of these forms in the United States that he did not include them in his synoptic table. Concerning the former species he wrote: "*F. cinerea* does not occur in North America; the form identified as such by Mayr will be described below as *F. pilicornis* n. sp." In regard to *F. rufibarbis* his statements are less positive: "For the present I am inclined to doubt whether forms belonging to the true *fusco-rufibarbis* series are actually indigenous to America. I am really unable to distinguish from rather pale and very pilose European *fusca* (*fusco-rufibarbis*) only three workers which were received from Colorado through Mr. Pergande. The precise locality of these specimens is not given."

More than a year ago Dr. Harold Heath of the Leland Stanford University sent me numerous specimens both of *F. cinerea* and *F. rufibarbis* which he had kindly collected for me near San Jose, California. The *F. rufibarbis* was compared with

[1] *Contributions from the Zoölogical Laboratory of the University of Texas*, No. 38.

[2] Die Formiciden der Vereinigten Staaten von Nordamerika, *Verhand. Zool.-Bot. Ges. Wien.*, Bd. xxxvi (1886), pp. 419–464.

[3] Beiträge zur Kenntniss der nordamerikanischen Ameisenfauna, *Zool. Jahrb.*, Abth. f. Syst., Bd. vii (1893), pp. 633–682, Taf. XXII, and Bd. viii (1894), pp. 257–360, Taf. VIII.

European specimens by Professor Emery, who reported as follows (*in litteris*): "It is the true European form, differing from our common type only in the total absence of erect hairs on the thorax. In this respect it approaches var. *glauca* Kusgky from Oriental Russia." It is possible that Dr. Mayr may have seen specimens of this same ant, but it is more probable that he had specimens of *neo-rufibarbis* Emery, a common form throughout the more western and southwestern states as far as the Pacific coast. The specimens of *cinerea* received from Dr. Heath were compared with European *cinerea* given me by Professor Emery, Professor Forel, and Dr. Mayr. The specimens from Professor Emery were collected near Bologna, Italy. They are decidedly smaller and have a darker ground color than the Californian specimens. These, however, agree very closely in their larger size and somewhat reddish coloration with the Austrian and Swiss specimens from Dr. Mayr and Professor Forel. I believe, therefore, that there can be no doubt concerning the occurrence in California of two species of Formica almost or quite identical with the European *cinerea* and *rufibarbis*. It is not so easy to decide whether one or both of these species are imported or indigenous to the American continent, but I know of no cogent reasons for accepting the former alternative. Certainly the occurrence of these species on the Pacific coast and their apparent absence from the eastern states of our Union are extremely suggestive in connection with the like geographical distribution of many other Pacific coast arthropods (Astacus, *e.g.*, many Diptera, and other insects) which are known to be more closely related to European genera and species than to those of the Atlantic states.[1]

After accustoming myself to view the distribution of the two species of Formica in this light, I was much surprised during August of the past summer to find *cinerea* very abundant in the vicinity of Rockford, Winnebago County, Ill. For several weeks of three successive summers I had collected very diligently without finding any such species in this locality. It

[1] See, *e.g.*, Osten Sacken's "Western Diptera." Cases in point are also the Californian ants of the subgenus Messor, and *Myrmica mutica* Emery, which is hardly more than a subspecies of the European *M. rubida*.

occurs most commonly, however, in such peculiar situations that there is little difficulty in understanding why it has been so long overlooked. The formicaries are so large and populous that it can hardly be regarded as an imported species unless it resembles some of the European weeds which have found the American soil so very favorable to their growth and expansion.

The following account of the localities in which I have taken *F. cinerea*, together with some notes on the structure of its formicaries, may prove to be of interest to students of insect distribution in general and of our American Formicidæ in particular. There are three of these localities some ten miles apart, in different directions and at least three to five miles from the town of Rockford, and in each of these localities, which are all open and exposed to the full heat of the sun, the nests are of a different type. August 20, I found a single nest, the first I had seen, under a small log in a meadow. This nest was not very populous and contained neither larvæ nor pupæ. It consisted of several inosculating galleries of the type usually made by species of Formica and extended down at least to a distance of 20 cm. into the black, waxy soil. The ants were timid, like the inhabitants of all small nests of Formica, and made no attempt to attack me. August 22, I found two very large nests side by side at the edge of a turnpike not far from a meadow. Each of these covered an area of somewhat more than a square meter, and each consisted of a flat mound of earth about 10 cm. high, strewn with little straws and sticks brought together by the ants. This débris concealed numerous openings from which the ants rushed forth as soon as the nest was disturbed. Excavation was difficult on account of the hardness of the soil, but it was easy to make out that the formicary consisted of a honeycomb of galleries 1–2 cm. in diameter and extended down into the soil to a depth of more than 30 cm. It was filled with worker larvæ and pupæ, together with thousands of ants, which attacked me furiously, using their jaws and formic acid batteries to good purpose. August 25, I discovered a locality where there are hundreds of *cinerea* nests. This is a meadow about a mile and a half long

and a quarter of a mile wide, surrounded by woods and corn fields. It is traversed by a cool stream, the banks of which for some distance on either side are boggy and thickly studded with large grass-covered hummocks. The *F. cinerea* have constructed their formicaries in these hummocks, which range from 30 cm. to 60 cm. in diameter at the base and from 20 cm. to 30 cm. in height. There are nests in nearly all stages of growth, but for the most part well-established and extremely populous, being, with the exception of the two nests above described, the most populous nests of Formica I have seen during the entire summer. The formicary is started in the summit of the hummock, but ultimately invades its whole earthy substance and extends to a depth of at least 30 cm. to 60 cm. into the black soil from which the hummock arises. In small or moderately large nests all the grass which originally covered the hummock remains intact and in excellent condition, but in the largest formicaries the grass on the summit is partly cut away by the ants and partly buried under the earth brought up from the galleries and the little straws, bits of twigs, leaves, etc., collected by the insects in obedience to an instinct which appears to be shared to a greater or less extent by all the species of Formica. This makes the large nests very conspicuous, although the numerous openings, all in the flattened or somewhat convex summit of the hummock, are hidden under the outermost layer of vegetable débris. The living grass forming the sides of the hummock gives the nest great stability and very efficiently protects it from being injured by the feet of the pasturing cattle. Excavation of larger nests shows that the hummocks are honeycombed throughout with a network of inosculating galleries abruptly terminating at the level of the moist, black meadow soil, into which only a very few long and more or less perpendicular galleries and chambers penetrate to a depth of 60 cm. and possibly farther.[1]

[1] During September, after this paper had been sent to the *Naturalist*, I happened on a fourth locality abounding in *cinerea* nests. This was a large meadow almost within the city limits of Rockford. It contained formicaries of all three types: under logs and stones, in the form of flat, irregular mounds and in modified hummocks.

These peculiar hummock formicaries occupy a zone on either side of the stream midway between the dryer and more boggy portions of the meadow, although a few of them reach quite to the edge of the stream and are even perforated by the burrows of frogs. The nests are so numerous as to be often within a meter's distance of one another. Along the outer edges of these zones, and mingled with the dryer *cinerea* nests, there are occasional nests of *F. subsericea* of precisely the same structure. The main zone of this species, however, lies on higher ground, where the hummock nests are replaced by true mound nests entirely constructed by the ants.[1]

There were some slight variations in size and coloration among the *F. cinerea* found in different nests in this locality, but these are all comparable to similar variations in European specimens. On the whole, the specimens from Illinois have the ground color of the head and thorax more or less reddish like the Californian and Austrian specimens. All the individuals examined have a number of hairs on the lower surface of the head. According to Emery this is the distinguishing trait of *cinerea* among all the European Formicidæ. In the United States *F. schaufussi* and *F. subpolita* and its varieties agree with *cinerea* in possessing such hairs, but they may be

[1] As Father Muckermann has shown in a recent paper (The Structure of the Nests of Some North American Species of Formica, *Psyche*, June, 1902, pp. 355–360), *F. subsericea* makes nests of at least four different styles: small flat moundlets in the grass with numerous apertures, nests in mounds capped with pieces of rock or wood, small nests beneath stones, and finally large mound nests. According to Father Muckermann the nests of the style last mentioned are neither as large nor of the same shape as those of *F. obscuripes* and *F. exsectoides*. This is true in general, but I have seen at the edges of fields in the environs of Milwaukee, whole colonies of grass-covered *subsericea* nests varying from 30 cm. to 1 in. in diameter and from 20 cm. to 30 cm. high, dimensions almost as great as those recorded by Father Muckermann for *obscuripes*. I may say in this connection that, like Father Muckermann, I do not altogether agree with Forel, who believes that the American are inferior to the European ants in mound building. As contradicting such a view, I would point to the large formicaries of *F. exsectoides* in the eastern states, to those of different varieties of *F. rufa* in different parts of the United States, to the species of Pogonomyrmex and Ischnomyrmex in the West and Southwest, and to the yellow species of Lasius (*L. aphidicola*, *claviger*, and *interjectus*) in Illinois. During the past summer I saw near Rockford a dome-shaped formicary of *L. interjectus* 1.5 meters in diameter at the base and 60 centimeters high, and I have seen many nests of this and the other yellow species of Lasius that were fully one-half to two-thirds as large.

readily distinguished by their coloration, which is never ashy or silvery gray. At first sight *F. subsericea* resembles *cinerea*, but the former never has hairs on the lower surface of the head. This character definitely separates the two forms, notwithstanding the fact that *subsericea* presents color variations in the direction of *cinerea*.[1]

The *cinerea* nests were not seen till it was too late in the year to secure the winged sexes, which, like the males and females of our other species of Formica, probably make their appearance during June and July. Even the deälated mother queens were found in but one of the smaller nests. All the nests, however, were full of worker larvæ and pupæ. The latter were generally enclosed in cocoons, but quite a number of nude pupæ were also seen in many of the nests. In this respect *cinerea* resembles the Formicidæ of the *pallide-fulva*, *fusca*, and *subpolita* groups, the worker larvæ of all of which, in contradistinction to *F. rufa* and its varieties, have a very pronounced tendency to omit spinning a cocoon just before pupation. At Rockford during the past summer many of the nests of these species contained only nude pupæ. This may have been due to the great amount of moisture in the nests, as June and July were unusually rainy. At any rate, I observed that the cocoons were relatively much more abundant during the dry weather late in August.

In its habits *F. cinerea* is very similar to the ants of the *fusca* group. It was seen in great numbers visiting the flowers in the meadow and attending great droves of Aphidæ on the willows along the stream. The walls of the galleries in some of the formicaries were tenanted by teeming colonies of the minute lestobiotic, or thief ant, *Solenopsis molesta* Say. In one *cinerea* nest I took a myrmecophilous histerid beetle (*Hetærius brunneipennis* Randall).

ROCKFORD, ILL., September 1, 1902.

[1] At Rockford I discovered two rather large nests of a form which should, perhaps, rank as a distinct variety of *F. fusca* allied to *subsericea*. The ants from these nests are smaller and more graceful in stature than the common *subsericea*, the legs and antennæ are red like those of *cinerea*, and the body is so thickly overlaid with silvery white, appressed pubescence that the black ground color is hardly visible. This form may be called *Formica fusca* var. *argentata* var. nov.

SYNOPSES OF NORTH-AMERICAN INVERTEBRATES.

XII. The Trematodes.

PART II.—THE ASPIDOCOTYLEA AND THE MALACOCOTYLEA, OR DIGENETIC FORMS (continued).

H. S. PRATT.

Key to the Species of North-American Aspidocotylea and Malacocotylea, so far as described.

Genus Stichocotyle.

Larva found in *Nephrops norwegicus* and *Homarus americanus*: length 3–7 mm., with 7–22 suckers. Adult in *Raja clavata*: length 17–105 mm., with 20–27 suckers . . . . *S. nephropis* Cunn. (Fig. 2) (62, 68)

Genus Cotylaspis.

Body white or pinkish: in various species of Unio and Anodonta
C. insignis Leidy (Fig. 5) (22, 23, 73, 16, 17)

Genus Cotylogaster.

Body elongate; anterior portion of body terminated by a five-lobed disk surrounding the mouth; sucking disk with 132–144 depressions; marginal sense organs present; from dorsal surface near posterior end rises a broad conical elevation, at base of which is excretory pore; length 8 mm.: in gut of sheepshead in Minnesota . . . . . *C. occidentalis* Nick. (66)

Genus Aspidogaster.

Number of depressions about 64; sucking disk elliptical, covering two-thirds of the body: in pericardium, liver, and kidney of Unio and Anodonta
A. conchicola v. Baer (Fig. 7) (20, 22, 23, 16, 17, 78)

Genus Paramphistomum.

a_1. Body ovoid or elliptical.
b_1. Acetabulum large; testes 2, lobate, in median line; 12 mm. long, 5 mm. wide: in intestine of Manatus
P. fabaceum Dies. (32)

b_2. Acetabulum emarginate; 4–24 mm. long, 2–12 mm. wide: in intestine of terrapin . . . . *P. grande* Dies. (29)

a_2. Body conical or subconical.

b_1. Acetabulum large and subterminal; testes lobate, median: in stomach of sheep and cattle . *P. cervi* Zed. (Fig. 9) (85, 87)

b_2. Acetabulum in ventral surface not quite at posterior end, emarginate; genital pore near anterior end often in a papilla or retracted in a depression; body triangular in cross section: in the muskrat *P. subtriquetrum* R. (45)

GENUS DIPLODISCUS.

Acetabulum large; body tapering anteriorly: in intestine of frogs *D. subclavatus* R. (Fig. 12) (21, 80, 79, 41)

GENUS FASCIOLA.

a_1. In mammals; worms of large size.

b_1. Worms 18–50 mm. in length, 4–13 mm. in breadth; anterior end distinctly set off from remainder of body; broadest part of worm in front of its middle: in cattle, sheep, deer, man, *et al.* *F. hepatica* L. (Fig. 13) (83, 85, 93)

b_2. Worms 20–100 mm. long, 11–26 mm. broad; anterior end indistinctly set off; broadest part of worm back of its middle; body flesh colored: in cattle . . *Dist. hepaticum* Curtice (83)
Dist. carnosum Hassall (83)
Dist. americanum Hassell (83)
Dist. texicanum Francis (83)
Dist. crassum Leidy (83)
= *F. magna* Bassi (83, 85, 93)

a_2. In birds; worms not of large size; body piriform; 14 mm. long: in lungs of kingfisher . . . . . *Dist. trapezium* Leidy (32, 81)
= *F. reticulata* R. Wr. (97, 44)

GENUS FASCIOLOPSIS.

Body nearly circular; 15 mm. long, 12 mm. wide; in liver of an Indian elephant (in Boston) . . . . . . *F. jacksoni* Cob. (Fig. 14) (83, 44)

GENUS PLEORCHIS.

Body linguiform; 14½ or 15 pairs of testes present; 5.25 mm. long, 1.5 mm. wide: in lung of a turtle (*Sternotherus odoratus*) *P. mollis* (Leidy) S. et H. (82)

GENUS PARAGONIMUS.

Body red in life; suckers small; ovary to left of acetabulum; 8–20 mm. long, 4–8 mm. wide: in lungs of cat and dog, *et al.*, and possibly encysted in the muscles of swine (Agamodistomum *sp.*) in a larval condition *P. westermanni* Kerb. (Fig. 17) (93, 87)

Genus Opisthorchis

a_1. Body not spinose, lanceolate; testes not at extreme hinder end of body; 10–21 mm. long, 1–2.5 mm. wide: in the liver of cats and the cayote . . . *O. pseudofelineus* Ward (Fig. 30) (94, 81. 93)

a_2. Body spinose, very elongate; testes at extreme hinder end of body; 12–29 mm. long, 1 mm. wide: in liver of crow *O. spesiosus* S. et H. (81, 84)

Genus Metorchis.

Uterus massed around acetabulum; body linguiform; testes large and lobate; 6 mm. long, 2 mm. wide: in cats *M. complexus* S. et H. (Fig. 32) (81)

Genus Telorchis.

Yolk glands extend in front of acetabulum; intestinal cœca extend beyond testes; 3.15 mm. long: in intestine of painted turtle *T. angustus* Stafford (79)

Genus Deropristis.

Anterior end usually attenuated and covered by large, coarse spines, remainder of body by short spines; acetabulum much larger than oral suckers; 3–6 mm. long, 1.2 mm. wide: in the intestine of *Phycis tenuis* *D. hispidus* Abil. (40, 70)

Genus Echinostoma.

a_1. Number of oral spines usually 37; 18 mm. long, 1.5 mm. wide: in intestine of muskrat . . . . *E. echinatum* Zed. (Fig. 25) (28)

a_2. Number of oral spines 45; 2.5 mm. long: in intestine of *Œdemia americana* . . . . *E. flexum* Linton (36)

a_3. Number of oral spines 27; body elliptical; 8 mm. long: in intestine of *Botaurus minor* . . . . *E. aspersum* R. Wr. (97)

Genus Stephanochasmus.

a_1. Number of oral spines 32, 16 being in each row; body cylindrical anteriorly, globose posteriorly; 2.5–3 mm. long: in capsules in peritoneum of filefish (*Alutera schoepfii*) *et al.* *S. valdeniflatus* Stoss. (38, 40)

a_2. Number of oral spines 42, 21 being in each row; body slender or lanceolate; pharynx very large; prepharynx long; intestinal cœca wide; 3 mm. long. 0.6 mm. wide: in rectum of striped bass (*Roccus lineatus*) . . . . *S. tenuis* Linton (38, 40)

a_3. Body elongate; pharynx large; prepharynx long; 3.15–4.5 mm. long, 0.5 mm. wide: in peritoneum of white perch (*Morone americana*) *S. tenuis tenuissimus* Linton (38)

a_4. Body elongate; 4.5 mm. long: in intestine of *Cottus scorpius*
S. sobrinus Lev. (33)

a_5. Number of oral spines about 48, 24 being in each row; body broad, lanceolate; testes and ovary in contact with each other; 1.14–1.85 mm. long, 0.37–0.64 mm. wide: in intestine of flounder (*Paralichthys dentatus*) . . . . *S. dentatus* Linton (39, 40)

Genus Rhopalias.

Body elongate, tapering towards the hinder end; tentacles long, being up to 1.3 mm. in length; prepharynx and œsophagus of about same length; 6–9 mm. long, 0.8–1.16 mm. wide: in intestine and stomach of opossum (*Didelphys virginiana*) . . . . *R. coronatus* R. (80, 7)

Subfamily Psilostominæ.

a_1. Body subcylindrical, anterior end cylindrical and very contractile, without spines; acetabulum larger than oral sucker; prepharynx, pharynx, and œsophagus present; yolk glands very voluminous and extend from acetabulum to posterior end, filling the body behind the testes, but not in front of acetabulum; 0.88–1.42 mm. long, 0.25 mm. wide: in intestine of hake (*Merluccius biliniaris*) *et al.*
Distomum vitellosum Linton (39, 40)

a_2. Body elliptical, depressed, anterior end cylindrical, contractile, without spines; yolk glands extend from pharynx in front of acetabulum to hinder end, usually not overlapping the intestinal cœca; prepharynx, pharynx, and œsophagus present; 1.6–2.74 mm. long, 0.57 mm. wide: in intestine of flounder (*Paralichthys dentatus*)
Distomum pudens Linton (39, 40)

a_3. Body elongate, linear, spinose; yolk glands extend from acetabulum to hinder end of body; prepharynx, pharynx, and short œsophagus present; 3 mm. long, 0.55 mm. wide: in intestine of cod
Distomum rachion (Cob.) Linton (38)

a_4. Body elliptical or piriform, covered with flat scalelike spines; acetabulum of same size as oral sucker in middle of body; ovary to right of and near acetabulum; yolk glands voluminous, extending from pharynx in front of acetabulum to hinder end of body, filling it back of testes; prepharynx, pharynx, and œsophagus present; 0.26–0.36 mm. long, 0.12–0.18 mm. wide: in pyloric cœca of rudder fish (*Palinurichthys perciformis*) *et al.*
Distomum pyriforme Linton (39, 40)

a_5. Body elliptical; acetabulum larger than oral sucker; anterior dorsal surface papillose; prepharynx, pharynx, and œsophagus present; yolk glands voluminous, occupying hinder half of body; 3.10 mm. long, 0.86 mm. wide: in intestine of filefish (*Alutera schoepfii*)
Distomum pallens (R.) Linton (38, 40)

a_6. Body elongate, without spines; acetabulum prominent, larger than oral sucker; yolk glands voluminous, back of acetabulum; 18 mm. long, 0.34 mm. wide: in intestine of tomcod (*Microgadus tomcod*) *Distomum simplex* (R.) Linton (38, 40, 33)

a_7. Body elliptical, spiny; a pair of groups of ocelli near mouth: acetabulum of same size as oral sucker; testes in oblique plane; prepharynx, pharynx, and œsophagus present; yolk glands voluminous, filling body back of acetabulum; 2–2.5 mm. long: in pyloric cœca of *Cottus scorpius* . . . . *Distomum oculatum* Lev. (33)

a_8. Body elongate, without spines, anteriorly cylindrical, posteriorly depressed; acetabulum larger than oral sucker, near middle of body; prepharynx, pharynx, and œsophagus present; testes and ovary in median line, close together; yolk glands voluminous, extending from acetabulum to hinder end; 1.78 mm. long, 0.33 mm. wide: in intestine of *Mola mola* *Distomum fragile* Linton (39, 40)

a_9. Body elongate, linguiform; prepharynx, pharynx, and œsophagus present; yolk glands voluminous, filling body back of testes; 4.35 mm. long, 1 mm. wide: in intestine of *Pseudopleuronectes americanus* . . . . . *Distomum globiporum* (R.) Linton (40)

Genus Crepidastomum.

a_1. Papillæ small; body elliptical: acetabulum smaller than oral sucker: pharynx and short œsophagus present: yolk glands voluminous, extending from pharynx to hinder end of body and overlapping intestinal cœca; 1.5–4 mm. long, 0.5–1.5 mm. wide: in rectum of Salmo . . . . *C. laureatum* (Zed.) Linton (37)

a_2. Papillæ large; body linear, tapering towards hinder end; oral sucker larger than acetabulum, but both large; œsophagus absent: yolk glands extend entire length of body; 1.7–2.2 mm. long, 0.6 mm. wide: in intestine of lake sturgeon (*Acipenser rubicundus*) *C. auriculatum* (Wedl) Linton (38)

Genus Azygia.

Body subcylindrical, light flesh color, posterior rounded. Ventral acetabulum ¾ line behind oral, ⅓ line in diameter. Oral acetabulum ¼ line. Length 8 lines; breadth posterior ½ line, anterior ⅓ line. Genital aperture before acetabulum: in stomach of Esox . *A. tereticollis* (R.) Leidy (21)

Genus Renifer.

a_1. Body elliptical; genital pore near left edge of body: 3–4.2 mm. long. 1.1–1.6 mm. wide: in mouth of *Heterodon platyrhinus* *R. ellipticus* Pratt (Fig. 53) (77)

a_2. Body elongate; genital pore near median line, but a little to left of it; 3 mm. long, 0.68 mm. wide: in mouth of *Heterodon platyrhinus* *R. elongatus* Pratt (77)

a_3. Body broad, piriform; genital pore near median line; 3–4 mm. long; 1.5–2 mm. wide: in lung of *Tropidonotus sipedon*
R. variabilis (Leidy) Lühe (21, 53, 77)

SUBFAMILY RENIFERINÆ.

a_1. Body elliptical; acetabulum smaller than oral sucker; testes small, spherical, in same transverse plane; ovary small, spherical, all three being near acetabulum in center of body; genital pore median, in front of acetabulum; 2.8 mm. long: in intestine of frog
Distomum quietum Stafford (79)

a_2. Body elongate, linear; acetabulum near anterior end; genital pore in front of it; testes spherical, in oblique plane, near middle of body; uterus voluminous, filling hinder part of body; yolk glands between testes and acetabulum; 6 mm. long: in ureter and kidney of *Boa constrictor* . . . . *Distomum horridum* Leidy (18, 21)

a_3. Body elliptical, without spines; acetabulum near middle of body; genital pore close to oral sucker; testes immediately behind acetabulum; 1.8–3 mm. long, 0.8–1 mm. wide: in mouth of *Tropidonotus sipedon*
Distomum aniorum Leidy (32)

a_4. Body elliptical; testes ovoid, in same transverse plane; ovary immediately behind acetabulum, which is larger than oral sucker and in middle of body; excretory vesicle wide and long; 3 mm. long: in intestine of *Cottus scorpius* . . *Distomum furcigerum* Olss. (33)

SUBFAMILY PLAGIORCHIINÆ.

Body elongate, with minute spines; uterus very voluminous; yolk glands a number of roundish masses distributed laterally along the middle region of the body; 2.8–5.5 mm. long, 0.6–1.12 mm. wide: in intestine of *Tylosurus carribæus* . . . . *Distomum nitens* Linton (38)

GENUS BUNODERA.

Intermediate host the crayfish (Cambarus), in which it is found in cysts in ovary and other organs; 1 mm. long
B. nodulosa Zed. (Fig. 45) (98, 35)

GENUS HÆMATOLŒCHUS.

Acetabulum very small: in lung of frogs
H. variegatus R. (Fig. 55) (20, 21, 97, 79)

GENUS OSTIOLUM.

Acetabulum minute; body elongate; median limb of excretory vesicle very long; 7–11 mm. long, 1.5 mm. wide: in frogs
O. formosum Pratt (Fig. 56) (77)

Genus Gorgodera.

a_1. In urinary bladder of frogs and salamanders; number of testes, 9; form of yolk gland, veriform

G. cygnoides Zed. (Fig. 62) (20, 21, 13, 22, 44)

a_2. Number of testes, 9; yolk glands deeply lobate, in form of a rosette; ovary lobate; 4.6 mm. long: in urinary bladder of *Rana catesbiana*, *R. clamitans*, *R. virescens* . . . . *G. amplicava* Lss. (2, 44)

a_3. Number of testes, 2; ovary veriform; yolk glands elongate and not lobate masses; 10 mm. long: in bladder of *Rana catesbiana*, *R. clamitans*, *R. virescens* . . . . . *G. simplex* Lss. (2, 44)

Genus Microphallus.

Body elliptical; œsophagus very long, intestinal cœca very short; 1.7 mm. long, 1 mm. wide: in intestine of *Amia calva et al.*; intermediate host *Cambarus propinquus* . . . . *M. opacus* Ward (Fig. 75) (92, 94, 74)

Genus Levinsenella.

Body elliptical; œsophagus very long; yolk glands consist of several distinct bodies; 0.5 mm. long: in intestine of *Somateria mollissima*

L. pygmæa Lev. (Fig. 71) (33, 15, 94)

Genus Cymatocarpus.

Body elliptical; intestinal cœca extend about to acetabulum; testes in oblique plane; 4 mm. long: in intestine of newt

C. hospitalis Stafford (79)

Genus Brandesia.

Body elliptical; acetabulum in hinder part; genital pore on left side in anterior half; intestinal cœca short and wide; ovary lobate between them; testes in nearly same transverse plane in hinder half of body; 2.5 mm. long, 1.75 mm. wide: in capsules in pyloris of frog . . *B. arcana* Nick. (64)

Genus Pleurogenes.

Body circular; 3–4 mm. long: in cysts in liver of bullfrog

P. medians (Olss.) Stafford (79)

Genus Gymnophallus.

Body elliptical; excretory crura extending to pharynx; 0.5 mm. long: in intestine of *Somateria mollissima* . . . . *G. somateriæ* Lev. (33, 69)

Genus Cephalogonimus.

Body elliptical; testes and ovary very near the acetabulum; œsophagus very short; yolk glands extend in front of acetabulum; excretory vesicle a

rounded sac into which radial canals extend; 2 mm. long: in intestine of soft-shell turtles (Aspidonectes and Amyda) . *C. vesicaudus* Nick. (65)

GENUS PROSTHOGONIMUS.

Body elliptical; acetabulum larger than oral sucker; 7 mm. long, 2.8 mm. wide: in the white of hen's egg, also in *Buteo lineatus* and *Corvus americanus* . . . . *P. ovatus* R. (Fig. 61) (34, 80)

GENUS DICROCŒLIUM.

Body elongate, lanceolate; suckers near together; testes lobate, close behind acetabulum; 4–10 mm. long, 1–2.5 mm. wide. "Stated to be frequent in sheep in several western states" (Leidy). "Apparently not in North America" (Stiles and Hassall): in cattle, sheep, man, etc.
D. lanceatum S. et H. (Fig. 82) (21, 84, 85)

GENUS LYPEROSTOMUM.

In *Corvus americanus* . . . . *L. plesiostomum* v. Linst. (80)

GENUS HEMIURUS.

a_1. Body cylindrical; appendix from a third the length to twice the length of the body; acetabulum much larger than oral sucker; testes not near acetabulum; yolk glands compact or slightly lobate; 0.5–6 mm. long: in stomach and pyloric cœca of marine fishes; intermediate host, copepods *D. pelagicum* Stafford (78)
= *H. appendiculatus* R. (Fig. 90) (39, 33, 55, 76, 24)

a_2. Body fusiform; appendix about a third the length of body; acetabulum larger than oral sucker; testes close to acetabulum; 1.5–3.5 mm. long: in *Macrourus bairdii* . . . . . *H. lævis* Linton (39, 55)

a_3. Body slender, cylindrical; appendix about a third the length of body; acetabulum larger than oral sucker; testes distant from acetabulum; yolk glands lobate; 5.12–5.4 mm. long, 0.75–1 mm. wide: in stomach of *Remora remora* . . . . *H. monticelli* Linton (39)

a_4. Body slender; appendix about a fourth the length of body; 3.2 mm. long, 0.42 mm. wide: in intestine of *Pomatomus saltatrix*
H. ocreatus (Mol.) Linton (39, 55)

GENUS LECITHOCLADIUM.

a_1. Body slender; appendix long; 8–15 mm. long, 0.7 mm. wide: in *Coryphæna hippurus et al.* . . *L. tornatum* (R.) Linton (38, 40, 55)

a_2. Body slender; appendix long and slender; acetabulum of same size as oral sucker; œsophagus wanting; testes just behind vesicula seminalis; the tubular yolk glands extending into appendix; 10 mm. long, 1.14 mm. wide, length of appendix, 3.6 mm.: in butterfish (*Rhombus triacanthus*) . . . . . *L. gulosum* Linton (40, 55)

Genus Lecithochirium.

Body cylindrical; 2–6 mm. long: in stomach of *Anguilla chrysypa*
L. grandiporum (R.) Linton (38, 55)

Genus Lecithaster.

Body fusiform; testes immediately behind acetabulum: 1–1.5 mm. long: in intestine of *Cottus scorpius* *Dist. mollissimum* Lev. (33)
= *L. bothryophorus* Olss. (Fig. 93) (44, 55)

Genus Pronopyge.

Body elongated, elliptical, flattened; 2–3 mm. long: in stomach of *Trichinous lepturus* . . . . *Dist. gastrocolum* Leidy (32)
= *P. ocreata* Mol. et R. (Fig. 92) (81, 55)

Genus Derogenes.

Body elongate; acetabulum very large, in middle of body: testes close to acetabulum; 2 mm. long: in stomach of *Cottus scorpius et al.*
D. varicus O. F. Mül. (33, 52)

Genus Progonus.

Body elliptical; acetabulum very large, in middle of body: 2 mm. long: in stomach of *Cottus scorpius et al.* . . *P. mülleri* Lev. (Fig. 84) (33)

Genus Halipegus.

Body elongated; acetabulum larger than oral sucker, in center of body; 10 mm. long: in Eustachian recesses and mouth of frog
H. ovocaudatus Vul. (Fig. 87) (63, 79, 53)

Genus Accacœlium.

a_1. Body cylindrical, "dorsal surface and lateral margins armed with spheroidal tuberculate spines"; "twenty flat spines, more or less, on the inner margin of the oral sucker"; 8 mm. long, 0.72 mm. wide: host? . . . . . *A. contortum* (R.) Linton (Fig. 80) (38)

a_2. Body cylindrical and slender: acetabulum larger than oral sucker and on a long peduncle; testes near center of body: no spines present; yolk glands "in slender, threadlike folds, centrally situated": 35 mm. long, 1.12 mm. wide: in intestine of *Mola mola*
A. nigroflavum (R.) Linton (38, 39)

a_3. Body cylindrical, without spines: acetabulum twice as large as oral sucker and pedunculate; 14 mm. long, 1.7 mm. wide: in intestine of *Mola mola* . . . . *A. macrocotyle* (Dies.) Linton (38, 39, 40)

a_4. Body cylindrical, slender; acetabulum pedunculate, "consisting of four foliate flaps"; 6–8 suckerlike structures in mid-dorsal line at anterior end of body; 12 mm. long, 1.28 mm. wide: in intestine of *Mola mola* . . . . *A. foliatum* Linton (38)

ALLIED TO GENUS ACCACŒLIUM.

"Body cylindrical, narrowest in fore part and obtuse behind; ventral bothria larger than mouth and projecting in advance in an extent equal to the body; skin smooth and transparent; yellow intestines and white and brown genitals shining through"; 20–45 mm. long, 0.5–1.5 mm. wide: in intestine of *Mola rotunda* . . . . . *Distomum pedocotyle* Leidy (31)

GENUS CLINOSTOMUM.

Body elongate; intestine with short side projections; yolk glands fill body back of acetabulum; cirrus sac before testes; 6–10 mm. long, 1–2 mm. wide: in mouth of *Ardea herodias et al.*; as young form in cysts in *Lepomis auritus et al.*

C. heterostomum (R.) R. Wr. et MacCallum (97, 56, 6)
Dist. gracile (Dies.) Linton (38, 6)
Dist. aquilæ Leidy (27, 81, 6, 85)
C. gracile Leidy (21, 81, 6)
Dist. galactosomum Leidy (30, 56, 6)
= *C. marginatum* R. (Fig. 101) (6)

ALLIED TO GENUS CLINOSTOMUM.

"Body elongated, elliptical, moderately wider and thicker posteriorly, unarmed." "Mouth subterminal and enclosed with a reniform lip, succeeded by a linear annulus. Acetabulum large, at anterior fourth of body." "Genital orifice at posterior fourth of body." Length 15–20 mm., breadth 3 mm.: in mouth of Alligator . . . . . *Distoma oricola* Leidy (25)

DISTOMIDS OF UNCERTAIN LOCATION IN THE SYSTEM.

PARASITIC IN MAMMALS.

Body elliptical and spinose; acetabulum in anterior half of body; genital pore halfway between it and posterior end of body; pharynx, short œsophagus, and long intestinal cœca present; testes large, obliquely behind one another in hinder part of body; ovary to right of them; 0.65–1.2 mm. long, 0.35–0.64 mm. wide: in intestine of Lepus
Distomum tricolor S. et H. (82)

PARASITIC IN REPTILES.

Body elongate; œsophagus wanting; testes obliquely behind one another in middle of body; ovary near acetabulum at anterior fourth of body; uterus between testes and ovary; yolk glands behind testes; 6 mm. long: in intestine of snapping turtle . . . *Distomum chelydræ* Stafford (79)

Parasitic in Amphibians.

Encapsuled under skin of *Siren lacertina* *Distomum sirenis* Vail. (90)

Body elliptical; intestinal cœca short, reaching to acetabulum; excretory vesicle large, the crura reaching to acetabulum; 0.7 mm. long, 0.45 mm. wide: in thoracic cavity of grass frog and encysted in anterior part of bullfrog . . . . *Distomum tetracystis* (Gal.) Stafford (79)

Body whitish, oblong, sublinear, narrowed anteriorly; oral sucker larger than acetabulum; 3 mm. long, 0.5 mm. wide: in *Rana halecina*
Distomum retusum (Duj.) Leidy (20, 21)

Parasitic in Fish.

Body elongate; suckers near each other, acetabulum somewhat pedunculate; genital pore in front of latter; 15 lines to 3 inches long, $\frac{3}{4}$ line wide: in mouth of Esox . . . . . . *Distomum longum* Leidy (20)

"Body long and narrow, band-like, with ventral disk at anterior fourth; smooth." "Ventral acetabulum about the width of body; oral disk smaller"; 8 mm. long, 0.87 mm. wide: in mouth, throat, and gills of sand pike (*Saurus fœtens*) . . . . *Distomum ischnum* Leidy (32)

"Body flat, elongated elliptical; echinated between oral and ventral acetabula, which are equal, and the latter one is hemispherical and sessile. Length $2\frac{1}{2}$ to 3 lines, breadth 3-5ths to 4-5ths of a line." In intestine of *Leiostomus obliquus* . . . . *Distomum incivile* Leidy (21)

"Body ovoid, anteriorly compressed, conical and incurved, posteriorly robust and obtuse." "Acetabulum much larger than mouth." "Genital pore a little in advance and to left of acetabulum, provided with prominent circular lip"; length $1-2\frac{1}{2}$ lines; breadth $\frac{1}{2}-1$ line: in gall bladder of unknown fish . . . . *Distomum biliosum* Leidy (23)

Body elongate, oval; 20 mm. long, 6 mm. wide: in body cavity of *Remora remora* . . . . *Distomum lageniforme* Linton (38)

Body elliptical, without spines; acetabulum larger than mouth; testes in same transverse plane near it; ovary in front of testes; intestinal cœca long; 1.25–6 mm. long, 0.7–2.6 mm. wide: in intestine of *Spheroides maculatus* . . . . *Distomum vibex* Linton (39)

Body wide and thick, without spines, bluntly rounded at both ends; acetabulum very large; œsophagus short, intestinal cœca long: testes and ovary close together in hinder part of body, the latter in front of former; uterus voluminous, filling body back of acetabulum; genital pore to right of pharynx; 2.75 mm. long, 1.4 mm. wide: in intestine of tilefish
Distomum fœcundum Linton (39)

Body broad, spiny: acetabulum small, in anterior half of body; œsophagus short, intestinal cœca long; testes behind ovary, side by side; genital pore to left of pharynx; 0.7–1.3 mm. long, 0.4–0.64 mm. wide: in intestine of white perch . . . . . . *Distomum areolatum* (R.) Linton (39)

"Head compressed oval, convex anteriorly; mouth minute, not bordered. Body compressed oblong oval. Ventral acetabulum immersed between body and head. Length $2\frac{1}{2}$ lines, breadth $\frac{2}{3}$ of a line." From the intestine of *Rusticola minor*

Distomum (Clinostomum) dubium Leidy (21, 6)

"Body elongated, sublinear, depressed, unarmed, transversely rugose, posteriorly attenuate. For about 6.5 mm. back of the ventral sucker the body was filled with the voluminous folds of the uterus"; 20 mm. long, 3.2 mm. wide: in stomach of *Raja lævis*

Distomum veliporum (Creplin) Linton (38)

Body cylindrical, posterior portion larger than anterior; testes side by side, immediately behind acetabulum; 18 mm. long, 4.5 mm. wide: in stomach of swordfish . . . . . . *Distomum clavatum* (R.) (21, 38)

PARASITIC IN MOLLUSKS.

Body oval; acetabulum large, in center of body; intestine convoluted, passing to extremity of body; genital orifice halfway between acetabulum and hinder extremity of body; length $\frac{1}{2}$ line, breadth $\frac{1}{4}$ line: in pericardium of *Helix alternata* and *H. albolabris* (intermediate host)

Distomum helicis Leidy (19, 21)
= *Distomum vagans* Leidy (18)

Body fusiform; suckers large; acetabulum near the middle of the body; oral sucker "with a style inserted in the upper lip"; 0.2 mm. long, .08 mm. wide: in liver of *Ilyanassa obsolata* . . . *Distomum lasium* Leidy (32)

PARASITIC IN CRUSTACEANS.

Body cylindrical; acetabulum larger than oral sucker; 1.25 mm. long; 0.4 mm. wide: in *Apus lucasanus* . . *Distomum apodis* Packard (75)

Body clavate, with a long, narrow tail (a cercaria); 0.25–0.4 mm. long: in muscles, liver, and intestine of Planorbis and Limnæa

Distomum ascoideum Leidy (24)

GENUS SCHISTOSOMA.

Male 4–14 mm. long, 1 mm. wide; female 13–20 mm. long, 0.28 mm. wide: in blood of man and cattle (?)

S. hæmatobium Bilh. (Fig. 107) (85)

GENUS KŒLLIKERIA.

Longer diameter of reniform portion 1.74 mm., shorter diameter 1.09 mm., diameter of neck 0.13 mm.: in cysts in intestinal wall of Spanish mackerel . . . . *K. filicolle* R. (Fig. 108) (40)

Genus Diplostomum.

a_1. Acetabulum and oral sucker small; special organ of attachment of a large cavity at bottom of a conical projection just back of acetabulum, in the center of which is a short canal leading to the cavity. 3–4 mm. long: in intestine of *Strix nivea et al.*
D. grande Dies. (23, 80)

a_2. Special organ of attachment open; acetabulum and oral sucker small; 1 mm. long, 0.35 mm. wide: a larval form found in cysts in liver of *Pomotis vulgaris et al.* . . . . *D. cuticola* Dies. (21, 38, 80)

a_3. Acetabulum large; oral sucker very small: anterior portion of body longer than hinder portion and not sharply separated from it; special organ of attachment an elliptical depression; 3.5–4.5 mm. long: in intestine of alligator . . . . . *D. pseudostomum* Will.-S. (96)

Genus Polycotyle.

Oral and ventral suckers small: 14 mid-dorsal suckers: 4.5 mm. long: in intestine of alligator . . . . . . *P. ornata* Will.-S. (Fig. 110) (96)

Genus Holostomum.

a_1. Body spinose, "divided by a constriction at the anterior third." "Head ovoidal, mouth terminal, round, opening into a cup-shaped pharynx"; 3.2 mm. long, 0.8 mm. wide: in intestine of *Rana pipiens*
H. nitidum Leidy (21)

a_2. Body not spinose; ventral sucker twice as large as oral sucker; ventral projection slit longitudinally into several parts and not extending beyond cup; 4–5 mm. long: in intestine of *Ardea herodias*
H. cornu Nitzsch (21, 80)

a_3. Anterior part of body subglobose, variable, aperture transverse; posterior cylindrical; reproductive aperture terminal, surrounded by a muscular border and with a central conical protractile part; 3 mm. long, 0.8 mm. wide: in intestine of *Circus cyaneus*
H. variabile Nitzsch (Fig. 113) (36)

Genus Gasterostomum.

a_1. Body elliptical; mouth in center of body; 4–6 mm. long: in pyloric appendages of *Cottus scorpius* . *G. armatum* Mol. (Fig. 114) (33)

a_2. Body ovate, being wider anteriorly: mouth towards anterior end; 1.9–2.7 mm. long, 0.92–1 mm. wide: in intestine of *Lobotes surinamensis*
Monostomum orbiculare (R.) Linton (38)
= *G. ovatum* Linton (39)

a_3. Body elongate; mouth towards anterior end; 1.28–2.7 mm. long, 0.21 mm. wide: in intestine of *Sarda sarda*
G. arcuatum Linton (39, 40)

Subfamily Pronocephalinæ.

Body elongate, lateral margins parallel; reniform projection at anterior end; intestinal cœca long and serpentine; testes lobate at hinder end; 18–25 mm. long, 3 mm. wide: in intestine of *Spargus coriacea*

Monostomum renicapite Leidy (21, 8)

Genus Opisthotrema.

Body broad, sagittate; testes small, lobate, in same transverse plane, laterad of intestinal cœca; ovary small, in front of testes; 10 mm. long; in Manatus . . . . *O. cochleare* Leuck. (Fig. 118) (80)

Genus Cyclocœlum.

Body elongate, attenuate anteriorly; 18 mm. long: in thoracic cavity of Gallinago *et al.* . . . . *C. mutabile* Zed. (Fig. 119) (26, 80)

Genus Notocotylus.

Body elongate, elliptical; testes in hinder end of body; 7 mm. long: in intestine of *Somateria mollissima et al.*

N. verrucosus Fröh. (Fig. 124) (33)

Monostomids of Uncertain Location in the System.

Body spatulate, broader posteriorly; oral sucker small; intestinal cœca long; 12 mm. long, 2 mm. wide: in bile ducts of muskrat

Monostomum affine Leidy (23)

Body elongate, elliptical, obtusely angular in front, obtusely rounded behind; 12 mm. long, 2 mm. wide: in stomach of jewfish (*Megalops thrissoides*) . . . . *Monostomum obscurum* Leidy (27)

Body flat, oblong ovate, narrowing anteriorly, obtuse posteriorly; 6 mm. long, 1 mm. wide: in fresh-water fish

Monostomum spatulatum Leidy (23)

Body ovoidal, anteriorly broad; 2 mm. long, 1 mm. wide: in body cavity of *Rana pipiens* . . . . *Monostomum ornatum* Leidy (21)

Body elongate, posterior quarter slightly broader; œsophagus very long; intestinal cœca short; genital pore at end of œsophagus in hinder half of body; 1.4 mm. long, .24 mm. wide: encapsuled under skin of *Siren lacertina*

Monostomum aspersum Vail. (80)

Body ovate, spiny; 8 testes, 4 on each side; ovary lobate in front of them; uterus voluminous; 2.3 mm. long: in *Opsanus tau*

Monostomum vinal-edwardsii Linton (40)

Body sagittate; hinder end truncated or concave; testes side by side, at extreme hinder end; ovary lobate, near center of body; 5 mm. long: in swimming bladder of catfish . . . *Monostomum amiuri* Safford (79)

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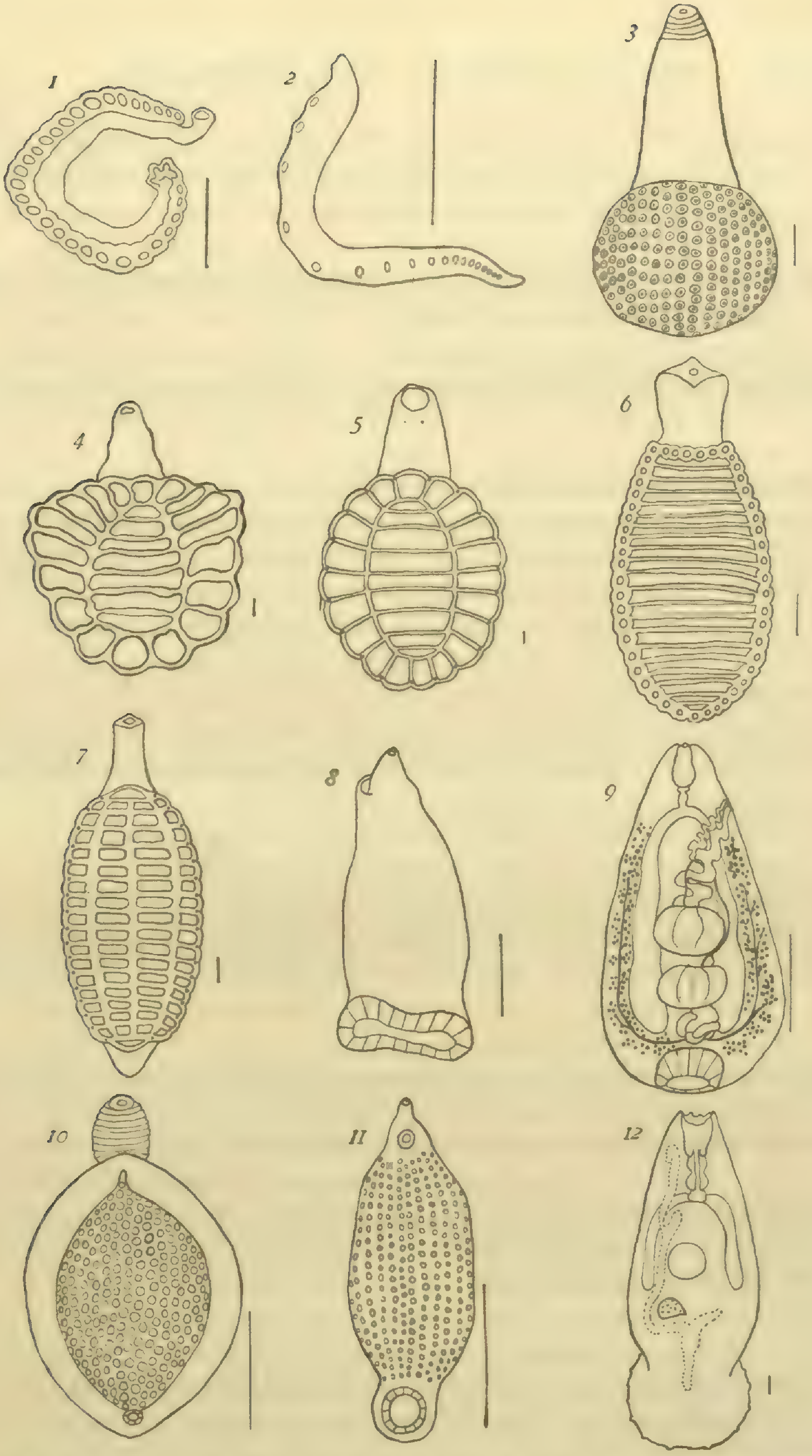

In these figures the ovary, when present, is indicated by being dotted: the receptaculum seminis, by being crossed by parallel lines; the yolk glands, by being solid black. The testes, intestine, and other organs are left white.

FIG. 1. Macraspis elegans Olss., after Monticelli (58). 2. Stichocotyle nephropis Cunn., after Nickerson (62). 3. Aspidocotylus mutabilis Dies., after Diesing from Bronn (3). 4. Platyaspis lenoiri Poir., after Poirier from Bronn (3). 5. Cotylaspis insignis Leidy, altered from Osborn (73). 6. Cotylogaster michaeli Mont., after Monticelli (58). 7. Aspidogaster conchiola v. Baer, after Monticelli (58). 8. Gastrothylax cobboldii Poir., after Poirier from Bronn (3). 9. Paramphistomum cervi Zed., after Laurer from Bronn (3). 10. Gastrodiscus polymastus Leuck., after Lejtényi from Bronn (3). 11. Homalogaster paloniæ Poir., after Poirier from Bronn (3). 12. Diplodiscus subclavatus Goeze, after Walter from Bronn (3).

FIG. 13. Fasciola hepatica L., after Stiles (83). 14. Fasciolopsis jacksoni Cob., after Stiles (83). 15. Campula palliata Lss., after Looss from Stiles (83). 16. Pleorchis polyorchis Stoss., after Stossich from Bronn (3). 17. Paragonimus westermani Kerb., after Ward (92). 18. Anoiktostoma coronatum Wag., after Stossich (88). 19. Centrocestus cuspidatus Lss., after Looss (43). 20. Ascocotyle minuta Lss., after Looss (44). 21. Rhopalias horridus Dies., after Braun (7). 22. Acanthochasmus scyphocephalus Brn., after Braun (8). 23. Anisocœlium capitellatum R., after Looss (48). 24. Anisogaster fallax R., after Looss (48). 25. Echinostoma echinatum Zed., after Looss (44). 26. Stephanochasmus cesticillus Mol., after Looss (44). 27. Dihemistephanus lydiæ Stoss., after Stossich and Looss (89, 44). 28. Telorchis parvus Brn., after Braun (8).

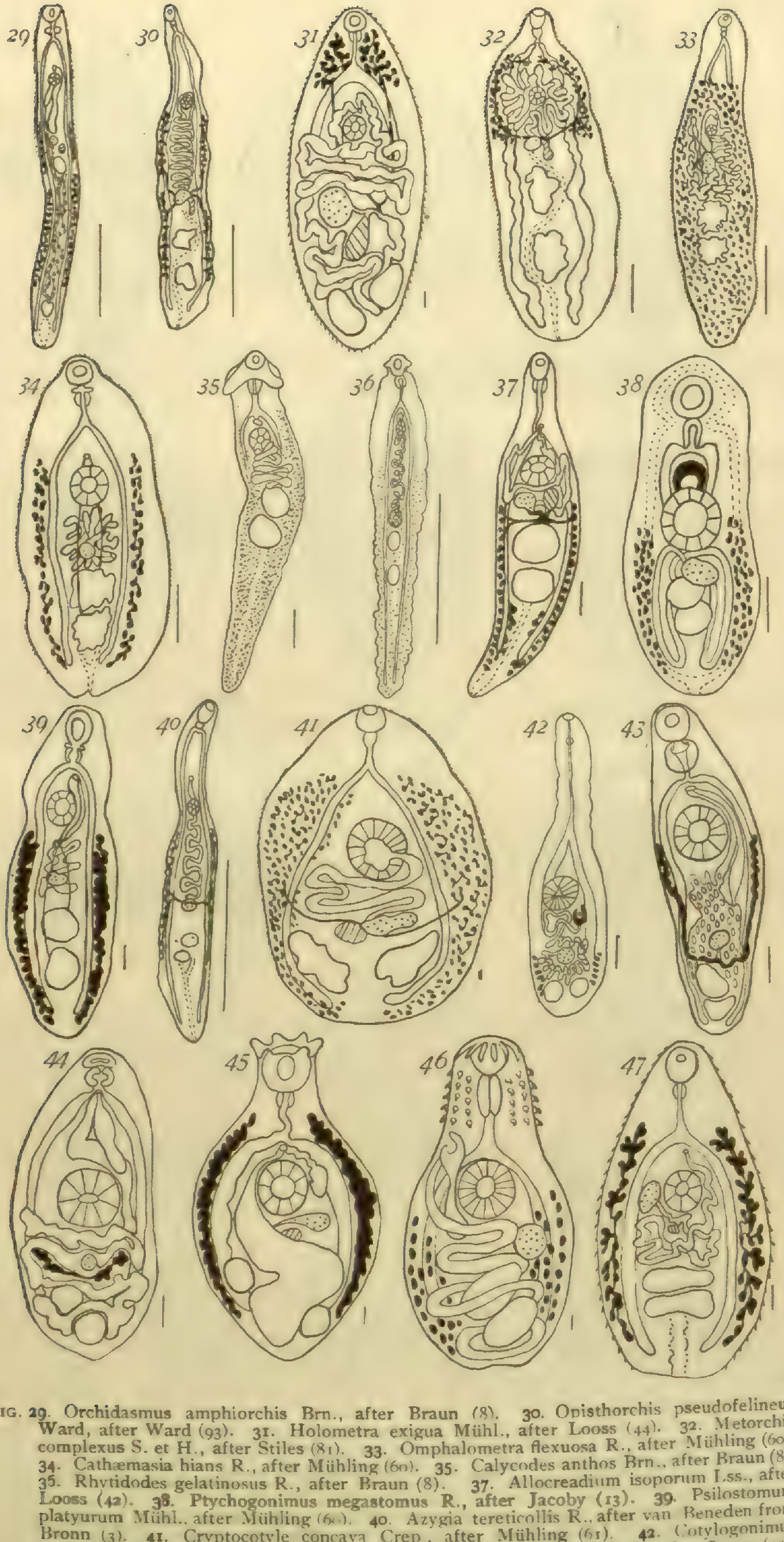

FIG. 29. Orchidasmus amphiorchis Brn., after Braun (8). 30. Opisthorchis pseudofelineus Ward, after Ward (93). 31. Holometra exigua Mühl., after Looss (44). 32. Metorchis complexus S. et H., after Stiles (81). 33. Omphalometra flexuosa R., after Mühling (60). 34. Cathæmasia hians R., after Mühling (60). 35. Calycodes anthos Brn., after Braun (8). 35. Rhytidodes gelatinosus R., after Braun (8). 37. Allocreadium isoporum Lss., after Looss (42). 38. Ptychogonimus megastomus R., after Jacoby (13). 39. Psilostomum platyurum Mühl., after Mühling (60). 40. Azygia tereticollis R., after van Beneden from Bronn (3). 41. Cryptocotyle concava Crep., after Mühling (61). 42. Cotylogonimus persicus Brn., after Braun (7). 43. Philophthalmus palpelabrum Lss., after Looss (44). 44. Pygorchis affixus Lss., after Looss (44). 45. Bunodera nodulosa Zed., after Looss (42). 46. Tergestia acanthocephala Stoss., after Stossich from Bronn (3). 47. Opisthioglyphe endoloba Duj., after Looss (42).

FIG. 48. Plagiorchis cirratus R., after Mühling (60). 49. Pachypsolus irroratus Brn., after Braun (8). 50. Glossidium pedatum Lss., after Looss (44). 51. Astiotrema impletum Lss., after Looss (44). 52. Styphlodora serrata Lss., after Looss (44). 53 Renifer ellipticus Pratt, after Pratt (77). 54. Endiotrema megachondrum Lss., after Looss (44). 55. Hæmatolœchus variegatus R., after Looss (42). 56. Ostiolum formosum Pratt, after Pratt (77). 57. Haplometra cylindracea Zed., after Looss (42). 58. Opisthogonimus phylodryochus West, after West (95). 59 Cephalogonimus lenoiri Poir., after Poirier from Bronn (3). 60. Emoleptalea exilis Lss., after Looss (44). 61. Prosthogonimus ovatus R., after Looss (44). 62. Gordodera cygnoides Zed., after Looss (42). 63. Phyllodistomum folium Oef., after Looss (42). 64 Anaporrhutum albidum Ofen., after Ofenheim (67). 65. Plesiorchorus cymbiformis Brn., after Braun (8).

FIG. 66. Stromylotrema singulare Mol., after Looss (44). **67. Asymphylodora perlata v. Nord.**, after Looss (42). 68. Pleurogenes medians Olss., after Looss (42). 69. Prosotocus confusus Lss., after Looss (42). 70. Gymnophallus deliciosus Odhner, after Odhner (69). 71. Levinsenella pygmæa Lev., after Jägerskiöld (15). 72. Cymatocarpus undulatus Lss., after Looss (44). 73. Brachycœlium heteroporum Duj., after Brandes from Bronn (3). **74. Pycnoporus acetabulus Lss., after Looss (44). 75. Microphallus opacus** Ward, after Ward (92). 76. Lecithodendrum ascidium v. Ben., after Looss (42). 77. Phaneropsolus **sigmoideus Lss., after Looss (44). 78. Brandesia turgidas Brds., after Looss (44).**

FIG. 79. **Eumegacetes triangularis** Dies., after Looss (44). 80. Accacœlium contortum R., after Monticelli (59). 81. Athesmia heterolecithodes Brn. 82. Dicrocœlium lanceatum S. et H., after Stiles (81). 83. Lyperosomum strigosum Brn., after Looss (44). 84. Progonus muelleri Lev., after Levinsen (33). 85. Otiotrema **torsum** Setti, after Looss (44). 86. Syncœlium ragazzi Setti, after Looss (44). 87. Halipegus **ovocaudatus** Vul., after Looss (42). 88. Liopyge bonnieri Mont., after Monticelli (59). 89. Derogenes minor Lss., after Looss (47). 90. Hemiurus appendiculatus R., after **Wagener**, altered (91). 91. Lecithocladium tornatum R., after Wagener, altered (91). 92. **Pronopyge** ocreata R., after Monticelli (57). 93. Lecithaster bothryophorus Olss., after **Levinsen** (33). 94. Lecithochirium digitatum Lss., after Looss (41). 95. Zoogonus mirus Lss., after Looss (47). 96. Zoogonoides viviparus Olss., after Odhner (70). 97. **Spærostoma globiporum** R., after Looss (42). 98. Urogonimus insignis **Lss., after Looss** (44). 99. **Urotocus** rossittensis Mühl., after Mühling (61). 100. **Hapalotrema constrictum** Lear., after **Looss** (44). 101. Clinostomum marginatum R., **after Braun** (6).

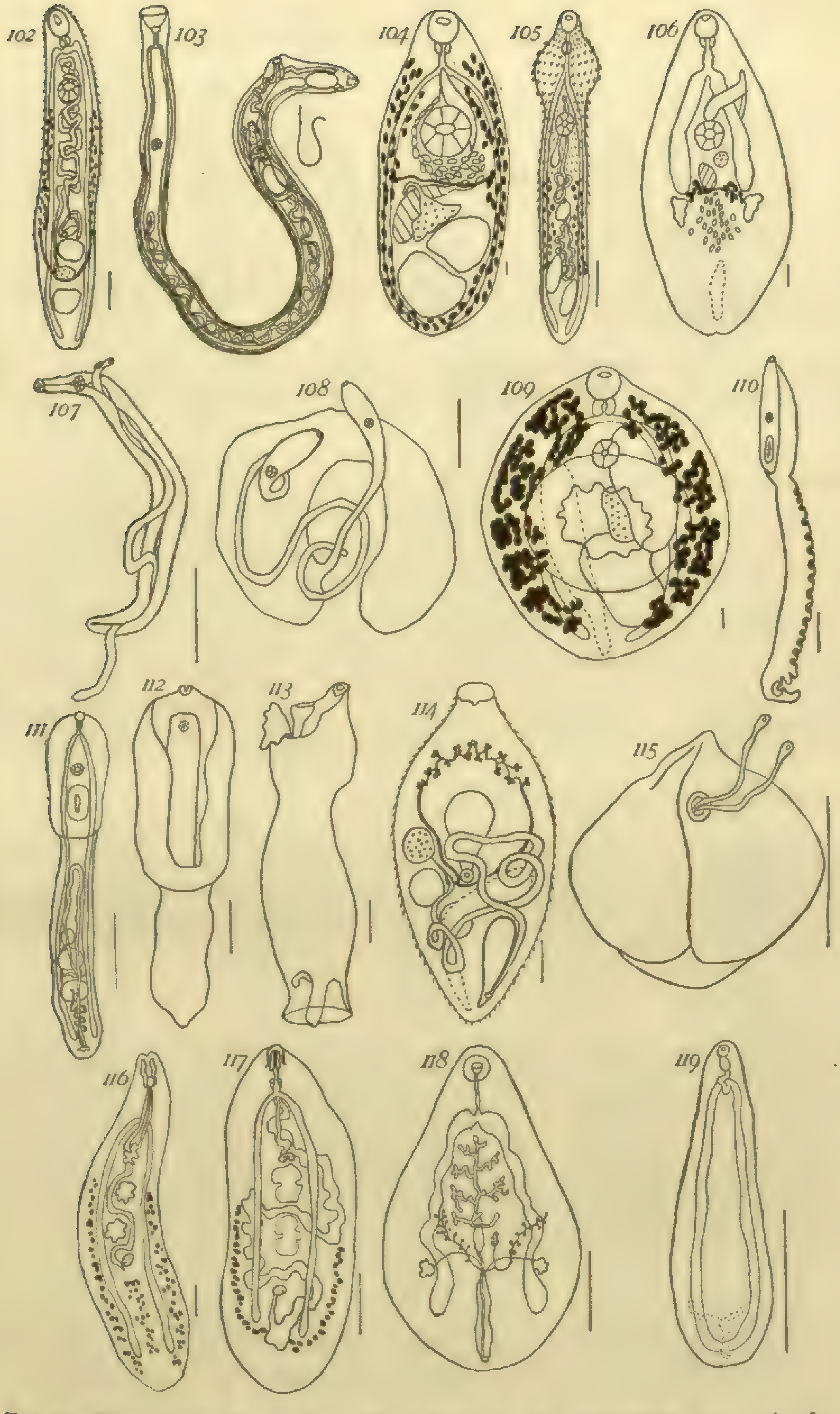

FIG. **102**. Harmostomum æquans Lss., after Looss (44). **103**. Ityogonimus lorus Duj., after Melnikow from Bronn (3). **104**. Halicometra pulchella R., after Odhner (70). **105**. Deropristis inflata Mol., after Stossich from Bronn (3). **106**. Lepidophyllum steenstrupi Odh., after Odhner (70). **107**. Schistosoma hæmatobium Bilh., after Looss (43). **108**. Kœllikeria filicolle R., after. Kölliker from Benham (1). **109**. Cyathocotyle prussica Mühl., after Mühling (60). **110**. Polycotyle ornata Wilh.-S., after Benham (1). **111**. Diplostomum longum Brds., after Brandes from Bronn (3). **112**. Hemistomum clathratum Dies., after Brandes from Benham (1). **113**. Holostomum variabile Nitz., after Benham (1). **114**. Gasterostomum armatum Mol., after Levinsen (33). **115**. Didymozoon thynni Tasch., after Wagener from Bronn (3). **116**. Microscaphidium reticulare v. Ben., after Looss (44). **117**. Deutobaris proteus Brds., after Looss (44). **118**. Opisthotrema cochleare Leuck., after Fischer from Bronn (3). **119**. Cyclocœlum mutabile Zed., after v. Ben. from Bronn (3).

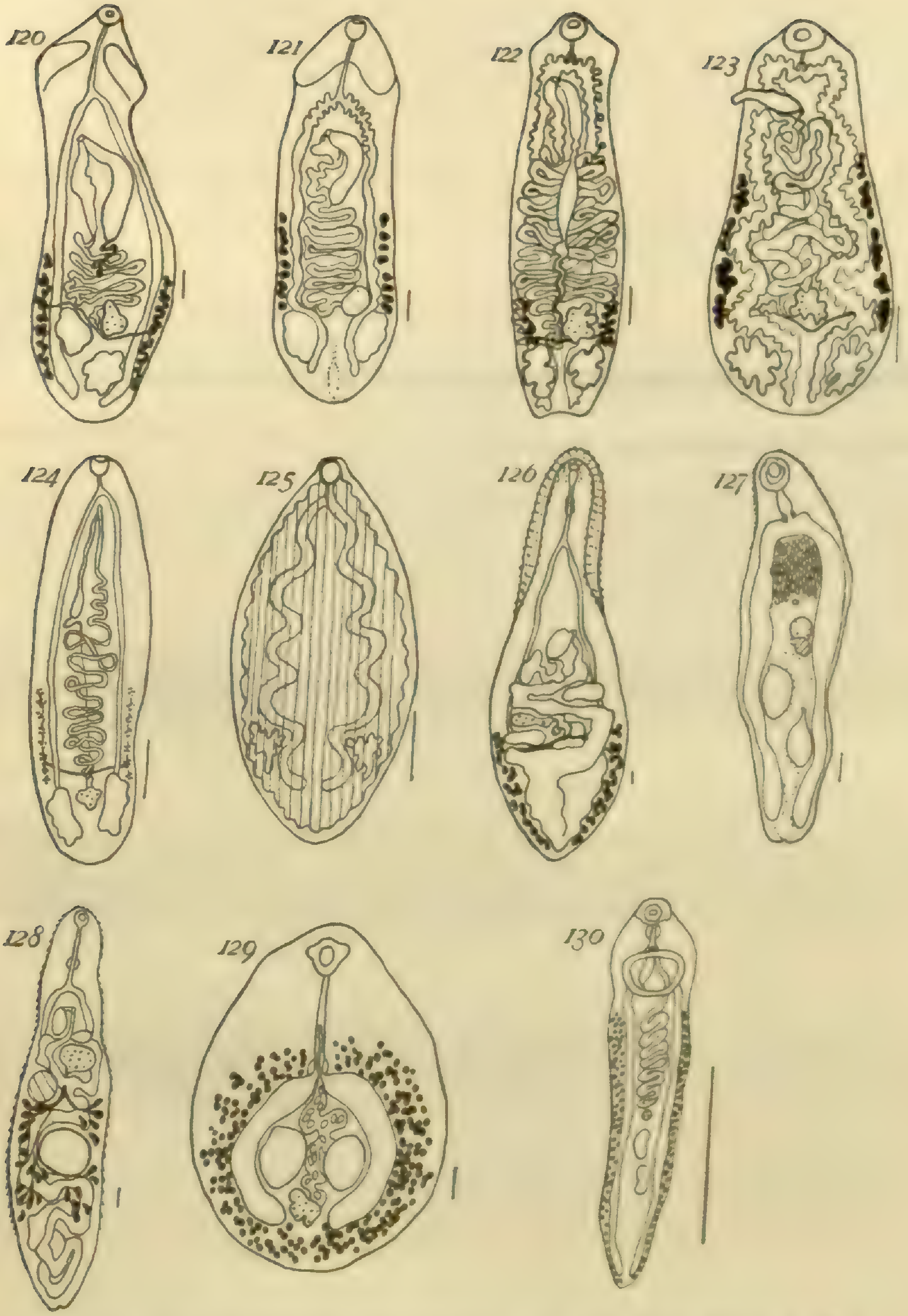

Fig. 120. Pronocephalus obliquus Lss., after Looss (44). 121. Pleurogonius trigonocephalus R., after Braun (8). 122. Cricocephalus delitescens Lss., after Looss (44). 123 Pyelosomum cochlear Lss., after Looss (44). 124. Notocotylus verrucosus Froeh., after Olsson (72). 125. Ogmogaster plicata Crep., after Jägerskiöld from Bronn (3). 126. Stictodora sawakinensis Lss., after Looss (44). 127. Galactosomum lacteum Jäg., after Jägerskiöld (14). 128. Haplorchis cahirinus Lss., after Looss (44). 129. Mesometra orbicularis R., after Lühe (54). 130. Cotylotretus rugosus Odh., after Odhner (71).

NOTES AND LITERATURE.

BOTANY.

Recent Literature on Germination.—The germination of the seed of *Carapa guianensis* Aubl. is described by Harshberger in *Proceedings of the Academy of Natural Sciences of Philadelphia*, Vol. LIV (1902), pp. 122–125, Pl. VIII. The seeds are without endosperm, the reserve material of the cotyledons being oil, proteid bodies, and protoplasm. The seeds would seem to lose their vitality more or less quickly; the period of germination is gone through quite rapidly, the plants reaching a height of about a foot and having produced several well-developed pinnate leaves in a month's time. They start to germinate before falling out of the capsule; all may germinate *in situ* and soon be so closely bound together by the intricately woven mass of secondary roots that it is hard to separate them. The germination of *Carapa guianensis* and *Xylocarpus granatum* (= *Corapa maluccensis*) is somewhat similar, the greatest difference being the formation of a tuber-like radicle and pneumatodes in *C. maluccensis*, a tree of mangrove habit.

Elenora Armitage finds (*New Phytologist*, Vol. I (June, 1902), pp. 127–128), that seeds of *Euphorbia peplus* germinate after being kept in a dry place for nearly nine years. She further shows that the seeds of this species, an annual, will germinate as soon as sown. The results are of interest in comparison with those of Winkler (*Berichte der deutschen botanischen Gesellschaft*, Vol. I), who found that seeds of *Euphorbia cyparissias*, a perennial, germinated first from four to seven years after they ripened, and those of *E. exigua*, an annual, nine years after ripening. She suggests that the so-called resting period is usually a delay due to the presence of a hard testa which requires moistening. It may be mentioned here that the seeds of *Nelumbium luteum*, for example, germinate at once when an opening is filed in the hard shell, but only after long delay when this is left intact.

In the *Journal of the Linnean Society*, Vol. XXXV (July, 1902), pp. 396–402, Prof. John Percival considers the origin of calcium oxalate crystals in seedlings of *Trifolium hybridum* Linn., giving the

results of a considerable series of experiments. In the same number of this journal Francis Darwin makes use of germinating Setaria, Sorghum, and *Vicia faba* in experiments on gravitational sensitiveness of the root tip.

A very interesting paper by Ethel Sargent, "The Origin of the Seed-Leaf in Monocotyledons" (*New Phytologist*, Vol. I, pp. 107–113, Pl. II), gives some of the results of five years' work on the vascular system in monocotyledons. She points out the fact that theoretically taxonomic characters drawn from the embryo are entitled to special attention in plants as in animals, but that so far the only important strictly embryonic character of acknowledged value is that employed in the fundamental division of the apparently well-defined group of angiosperms. Concluding that a detailed study of the seedlings of one family would yield results of greater value than a general study, work for the last four years has been confined to the Liliaceæ, of which seedlings of sixty genera have been collected and preserved, but the detailed examination of which is not yet completed. She considers that there is now no doubt of the systematic value of the indications given by the vascular structure of the cotyledon, hypocotyl, and primary root. At the same time, these indications she considers not easy of interpretation, since they are often wholly or in part concealed by adaptive characteristics which are the effect of environment upon an organism at a time when it is so little differentiated as to be extraordinarily plastic. In the hypocotyl she found the effects of this influence the least marked, but even here the structure must be affected by alternations in that of the cotyledon and root. In Anemarrhena she found a type of vascular arrangement from which others have clearly been derived, and that this form is truly symmetrical throughout. This type seems to be the starting point of at least four central tribes in the Liliaceæ, and must therefore be a form of some antiquity among monocotyledons. A comparison of some Ranunculaceæ, especially Eranthis, Nigella, and *Ranunculus ficaria*, of well-known monocotyledonous affinities, strengthened her opinion that the Anemarrhena type is a dicotyledonous one, and to conceive of steps by which two separate cotyledons may gradually unite, is, she thinks, easier than to conceive of a single cotyledon splitting into two similar members, as suggested by Lyon for Nelumbium. In conclusion, she says that there is no evidence of weight for the superior antiquity of monocotyledons, and that in this group the complete union of two cotyledons may possibly be due to their common specialization as an absorbing organ.

J. A. Harris.

Leaves of aquatics. — McCallum[1] gives the results of experiments designed to discover the factors determining the production of the well-known air and water forms of leaves in *Proserpinaca palustris*. After describing the form and anatomy of the two types of leaves, he gives the results of his experiments, which seem to show that the production of the submerged, much-dissected type, or the aërial, simply serrate type, is not determined by difference in illumination, nutrition, depth of water, temperature, stimulating influence of salts, variation of concentration of CO_2 or O, or contact stimulus. When, however, the plants were grown in a saturated atmosphere, a type of leaf very close to the regular submerged type is produced, and when plants grown under water are subjected to artificial transpiration induced by a change in osmotic pressure secured by a solution of mineral salts in the water, the air type of leaf was produced. Further experiments, the results of which will be presented later, are in progress.

J. A. Harris.

Notes. — The *American Journal of Pharmacy* for September contains an article on *Hyoseyamus muticus*, by Nagelvoort, and an account of the drug and medicinal-plant investigations in the Department of Agriculture, by True.

In the *American Journal of Science* for September, Fernald discusses the relationship of some American and Old-World birches; Sellards describes the fertile fronds of Crossotheca and Myriotheca, and the spores of other Carboniferous ferns, and also the validity of *Idiophyllum rotundifolium*, a fossil plant from the Coal Measures.

The *Bulletin of the Torrey Botanical Club* for August contains the following articles: Slosson, "The Origin of *Asplenium ebenoides*" (including the results of artificial hybridization of *Camptosorus rhizophyllus* and *Asplenium platyneuron*, and confirming the assumed hybrid nature of *A. ebenoides*, except that the artificial hybrids have not yet been made to fruit); Evans, "Hepaticæ of Puerto Rico"; White, "The Saltatory Origin of Species"; and Eastwood, "New Western Plants."

In Engler's *Botanische Jahrbücher* of August 29 are published the conclusion of Miss Perkins's "Beiträge zur Kenntnis der Stryracaceæ"; a monographic synopsis of the genus Lisianthus, by the same

[1] McCallum, W. B. On the Nature of the Stimulus causing the Change of Form and Structure in Proserpinaca palustris, *Botanical Gazette*, vol. xxxiv (August, 1902), pp. 93–108, Figs. 1–10.

author; a paper on *Nectria moschata*, by Glück; one on the anatomy of Anonaceæ, by Beyer; a study of Berberidaceæ, by Tischler; a supplement to Miss Perkins's monograph of Monimiaceæ; a paper by Hennings, on the fungi of Japan; a discussion of the wind as a factor in plant geography, by Warming; and a paper on the geographical distribution of mosses in middle Europe.

The Beiblatt, No. 70, of the same number, contains Dr. Clements's paper on a system of nomenclature for phytogeography, read in Denver last year, with concise comments by Professor Engler, and No. 4 of Urban's "Plantæ novæ americanæ, imprimis Glaziovianæ," dealing with palms, and written by Dammer.

The *Ottawa Naturalist* for September contains a paper on the arboretum and botanic garden at Ottawa, and a short account of the plants at Norway Bay, Bristol, both by W. T. Macoun.

Professor Greene, who had thought of discontinuing *Pittonia* at the conclusion of the fourth volume, has decided differently, and under dates of September 9 and September 18 issues the first fifty-six pages of the fifth volume. These two installments include the following papers: "New or Critical Species of Acer," "A New Study of Microseris," "Some Phacelia Segregates," "Segregates of *Viola canadensis*," "Some New Acaulescent Violets," "Revision of Romanzoffia," "Revision of Capnorea," "New Species of Cryptanthe," and "A Fascicle of New Compositæ."

Torreya for September contains the following articles: Kirkwood, "The Vegetation of Northwestern Oregon"; Peirce, "Extrusion of the Gametes in Fucus"; Lloyd, "Mutual Irregularities in Opposite Leaves"; Earle, "A Key to the North American Species of Lactarius"; Kraemer, "The Pith Cells of *Phytolacca decandra*"; and Rydberg, "A New Station for *Isotria affinis*."

K. K. Mackenzie and B. F. Bush have issued a manual of the flora of Jackson County, Missouri, which includes descriptions of 1141 species and 50 additional varieties, contained in 500 genera. This differs from the usual local floras in being a descriptive handbook, with keys to the higher groups and to the species of the larger genera.

In the *Sierra Club Bulletin* for January Miss Eastwood gives an account of Trinity County, California, with a list of the trees and shrubs found in that county.

The shrubs of Wyoming form the subject of *Bulletin 54* of the Wyoming Experiment Station, written by Elias E. Nelson.

The *Bulletin of the Geographical Society of Philadelphia* for April contains a report of the Brown-Harvard expedition to Labrador in 1900, and includes an extensive account of the botany of the expedition, with lists of the plants collected.

The *West American Scientist* for August, selling for ten cents, and Mr. Orcutt's *Review of the Cactaceæ* for the same month, selling for twenty-five cents, consists of the same signature of cactus notes.

A photogram of *Echinocactus cylindraceus* is contained in the August number of the *Monatsschrift für Kakteenkunde.*

Die Gartenwelt of August 23 contains an article on noteworthy trees of Hanover, illustrated by a number of pictures of trees growing under unusual conditions and displacing objects in their way.

Fasciation in the leaves of *Euonymus japonicus* is described by De Camps in the *Memorias de la Real Academia de Ciencias y Artes de Barcelona,* Vol. IV, No. 20.

The exhibition of botanical objects under the microscope in museums is the subject of an illustrated article by Howe in the *Journal of the New York Botanical Garden* for September.

The *Yearbook of the Department of Agriculture* for 1901, in addition to the usual administrative and statistical portions, contains a large number of economic articles, many of them of botanical interest.

The many publications of the U. S. Department of Agriculture, including those issued by the Patent Office, have been listed by the division of publications of the department in a recently issued bulletin, which will prove very serviceable to libraries possessing sets of these publications. A catalogue of the botanical publications in the library of the same department, by Miss Clarke, constitutes *Library Bulletin No. 22* of the department.

An interesting item in *Advance Sheets of Consular Reports* of August 30 shows that during July one hundred and eighty thousand bunches of bananas were shipped from Puerto Cortes, Honduras, to New Orleans and Mobile, and one hundred thousand additional bunches were paid for and destroyed by the contractors.

An economic study of berseem (*Trifolium alexandrinum*), much cultivated in the Nile valley, forms the subject of *Bulletin No. 23* of the Bureau of Plant Industry of the U.S. Department of Agriculture, written by Fairchild.

Nos. 50 and 51 of the *Contributions from the Cryptogamic Laboratory of Harvard*, published respectively as Nos. 2 and 3 of Vol. XXXVIII of the *Proceedings of the American Academy of Arts and Sciences*, are: "Preliminary Diagnoses of New Species of Laboulbeniaceæ," V, by Thaxter; and a paper on *Cauloglossum transversarium*, by Johnston.

A monograph of the Acrasieæ, by E. W. Olive, forms No. 6 of the current volume of the *Proceedings of the Boston Society of Natural History*. This is another of the foundation-laying studies from the cryptogamic laboratory of Harvard.

A biographical sketch of Marc Micheli, with an excellent portrait, has been distributed by M. de Candolle, from the *Archives des Sciences Physiques et Naturelles* for July.

CORRESPONDENCE.

Editor American Naturalist:

In the July number of the *American Naturalist*, among his "Notes on the Cœlenterate Fauna of Woods Hole," Dr. C. W. Hargitt has defined what he considers to be a new species of tubularian hydroid, under the name of *Tubularia parasitica*. During the past summer I have been enabled to observe the development of the western representative of the genus *Corymorpha*, *C. palma*, a few facts concerning which will show, I think, that *T. parasitica* is but a young form of the *pendula* on which it was growing. It has seemed best that attention should be called to this at once to prevent future inconvenience to taxonomists.

As with *C. pendula*, the medusæ of *C. palma* are permanently attached. The eggs arise on the manubrium, break through the ectoderm when ripe, and, in quiet water, settle at once to the bottom. The egg case is adhesive, fastening to the first object with which it comes in contact. Many eggs are dropped at the same time, and often cling to the rootlets of the parent hydroid, where *T. parasitica* was found. There is no free larval stage. The embryo is able, however, to change its location very slowly, leaving a trail of perisarc behind it. Such a movement accounts for the clusters of six or eight individuals which are commonly found adhering to each other near their bases. The stem has a single central canal at first, as in Tubularia. The peduncles which support the medusæ appear very early. When there are not more than eight proximal tentacles, buds arise on the base of the hydroid and develop into rootlets. They are the structures, I suspect, which Dr. Hargitt has taken for "absorbent organs."

The young Corymorpha further agrees with *T. parasitica* in size, number of tentacles, and general aspect.

I shall describe the development of *C. palma* more fully in another connection.

HARRY BEAL TORREY.

ZOÖLOGICAL LABORATORY, UNIVERSITY OF CALIFORNIA,
BERKELEY, CAL., Sept. 5, 1902.

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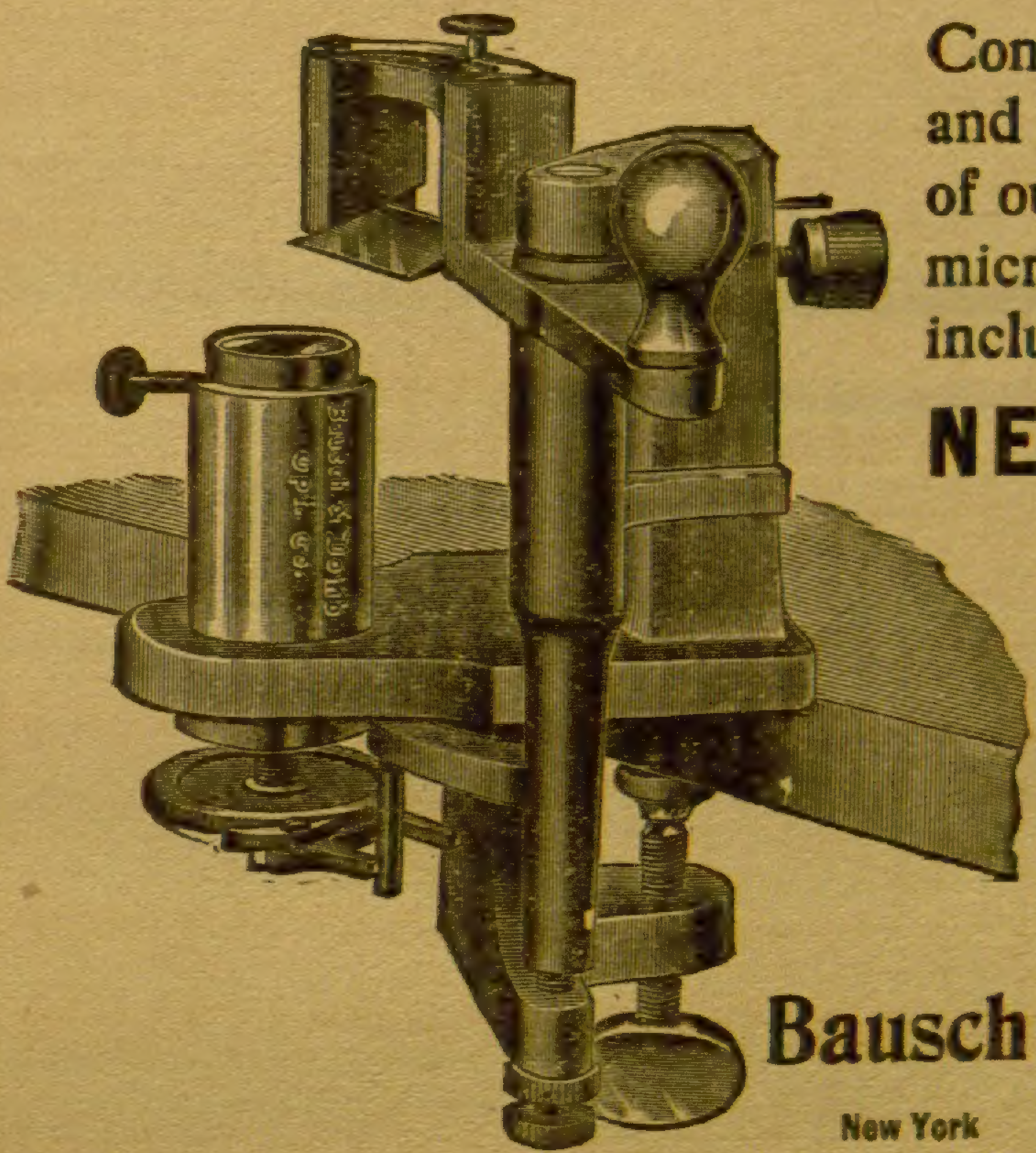

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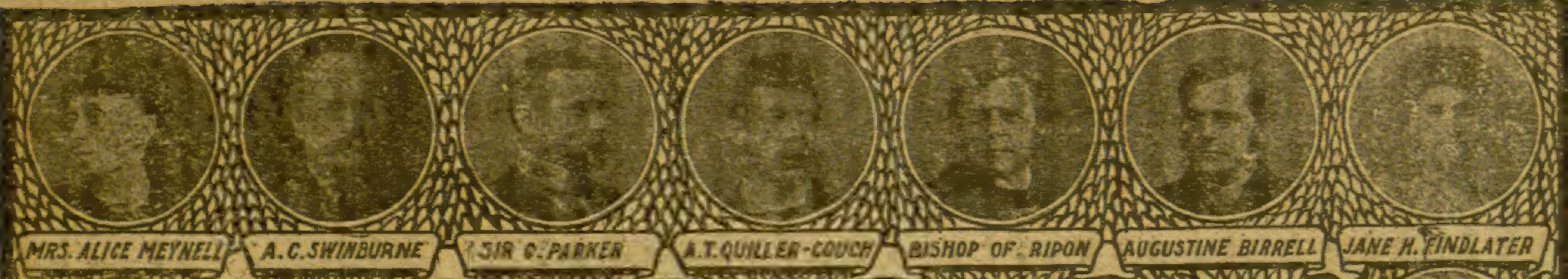

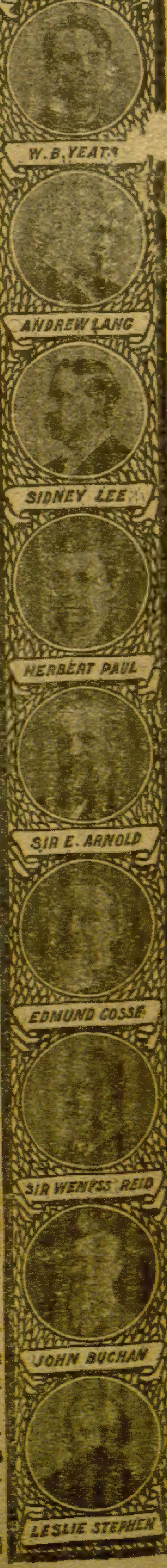

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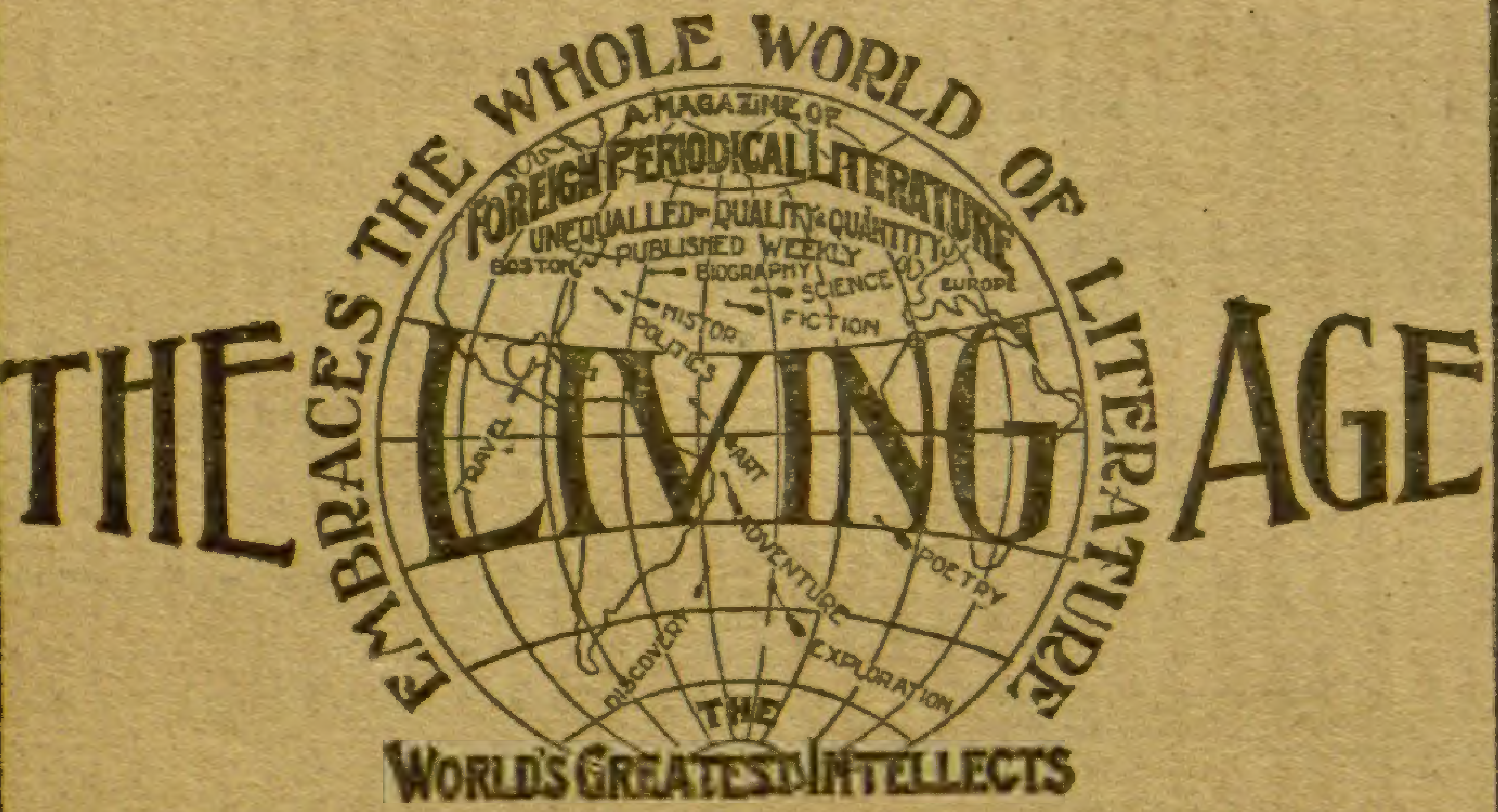

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